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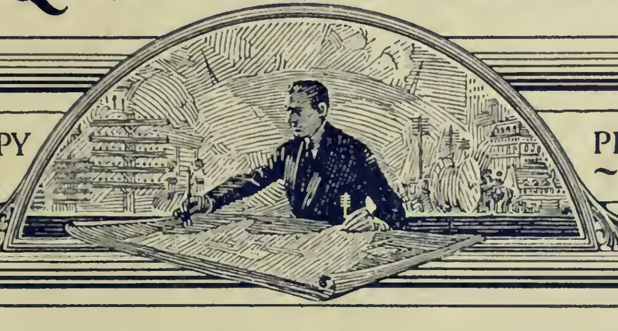

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VOLUME XII, 1933

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and a Record of Progress

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Engineers and Progress

An Address Given at the Annual Dinner of the Society of Automotive Engineers, January 11, 1933

TO the casual observer, the automobile and the telephone do not seem to be at all similar. They do not look much alike, they are not very much alike in their mode of operation. There are, however, certain fundamental similarities between these two devices and the uses that are made of them. Each gives to us an opportunity to make further extension of our personality. By means of the automobile, we may move rapidly from one place to another and bring ourselves into personal contact with others at a distance. By means of the telephone, without moving from one place to another, we may bring ourselves in contact with people at a distance and carry on communication by the spoken word. Both transportation and communication are fundamentals of our modern social structure.

There are other resemblances between the telephone and the automobile. Each is both mechanical and electrical in its nature. In the telephone, perhaps the electrical part predominates; in the automobile, the mechanical part predominates. Electricity and mechanics are, however, essential to both. Each is a product of fundamental ideas developed in the Nineteenth Century. Each was relatively undeveloped at the beginning of the Twentieth Century and attained its growth in this century. There are twenty times as many telephones in use today in the United States and in the world as there were at the beginning of the century and the relative number of automobiles now and then is even greater. Each has shown its greatest development in this country.

Each has been dependent in the past on science and engineering for its development and likewise will be dependent upon these for its further progress. The development work on each has been largely done within the industry. And, last but not least, each feels the present depression.

After reading some of the history of the social and economic world during the last two or three hundred years, it is curious to note how much surprise there is at the present time in regard to this depression. It is, generally speaking, regarded as something quite novel, quite unprecedented, and it is seriously questioned by many whether we will come out of it. I should like to say something if I can that will remove this idea from your minds. We seem to think of depressions as people in the earlier times thought of a total eclipse of the sun. It was new to them and they were terrified by it, and they did not know whether it would ever end, or how. Today we are not terrified by eclipses.

I should like to read to you a quotation from an article written by Macaulay, the British essayist, and published in 1830, over 100 years ago, in the *Edinburgh Review.*

> The present moment is one of great distress. But how small will that distress appear when we think over the history of the last forty years;—a war, compared with which, all other wars sink into insignificance;—taxation, such as the most heavily taxed people of former times could not have conceived;—a debt larger than all the public debts that ever existed in the world added together. . . .
>
> If we were to prophesy that in the year 1930, a population of fifty millions, better fed, clad, and lodged than the English of our time, will cover these islands . . . —that machines, constructed on principles, yet undiscovered, will be in every house,—that there will be no highways but railroads, no travelling but by steam,—that our debt, vast as it seems to us, will appear to our greatgrandchildren a trifling encumbrance, which might easily be paid off in a year or two,—many people would think us insane. . . .
>
> Hence it is, that though, in every age, every body knows that up to his own time progressive improvement has been taking place, nobody seems to reckon on any improvement during the next generation.
>
> We cannot absolutely prove that those are in error who tell us that so-

ciety has reached the turning point—that we have seen our best days. But so said all who came before us, and with just as much apparent reason. . . .

This article by Macaulay was written in 1830 and not in 1930.

Now let us look at something which was said in our own country in New Haven, Connecticut, in 1837, 95 years ago.

> A few months ago, the unparalleled prosperity of our country was the theme of universal gratulation. Such a development of resources, so rapid an augmentation of individual and public wealth, so great a manifestation of the spirit of enterprise, so strong and seemingly rational a confidence in the prospect of unlimited success, were never known before. But how suddenly has all this prosperity been arrested! That confidence, which in modern times, and especially in our own country, is the basis of commercial intercourse, is failing in every quarter; and all the financial interests of the country seem to be convulsed and disorganized. The merchant, whose business is spread out over a wide extent of territory, and who, regarding all his transactions as conducted on safe principles, feared no embarrassment, finds his paper evidences of debt, and acceptances and promises which he has received in exchange for his goods, losing their value; and his ability to meet his engagements is at an end . . . and loss succeeds to loss, till he shuts up his manufactory and dismisses his laborers. The speculator who dreamed himself rich, finds his fancied riches disappearing like an exhalation. . . .
>
> Already, in many a huge fabric that but a few days since resounded with the roar of enginery, all is silent as in a deserted city. . . . Already want, like an armed man, stands at the threshold of many a dwelling, where a few days ago, daily industry brought the supply of daily comforts. . . .
>
> Amid these present calamities, and these portentous omens of the future, it is not strange that many minds are seeking, and all voices are debating, the cause and the remedy.

Note the reference nearly 100 years ago to the speculator who dreamed himself rich and finds his fancied riches have disappeared.

Let us now step ahead a little in time and consider an extract from an editorial which was published in *Harpers' Weekly* in 1857, about 75 years ago.

It is a gloomy moment in history. Not for many years—not in the lifetime of most men who read this paper—has there been so much grave and deep apprehension; never the future has seemed so incalculable as at this time. In our country there is universal commercial prostration and panic, and thousands of our poorest fellow-citizens are turned out against the approaching Winter without employment, and without the prospect of it.

In France the political cauldron seethes and bubbles with uncertainty; Russia hangs as usual, like a cloud, dark and silent upon the horizon of Europe; while all the energies and influences of the British Empire are sorely tried, and are yet to be tried more sorely.

It is a solemn moment, and no man can feel an indifference in the issue of events.

Of our own troubles no man can see the end. . . .

Note the gloom and note the reference to the European situation.

Now moving forward to 1886, let us consider a brief abstract from the First Annual Report of the U. S. Commissioner of Labor, Carroll D. Wright, written and published 47 years ago.

The rapid development and adaptation of machinery in all the activities belonging to production and transportation have brought what is commonly called over-production, so that machinery and over-production are two causes so closely allied that it is quite difficult to discuss the one without taking the other into consideration. . . . On all sides one sees the accomplished results of the labor of half a century. From a financial point of view, these accomplished results should always be good, but in many cases it is apparent that undertakings have proved deceptive and Governments become needy and some . . . insolvent. Whatever may have been the financial results, industry has been enormously developed, cities have been transformed, distances covered, and a new set of economic tools has been given in profusion to rich countries, and in a more reasonable amount to poorer ones. What is strictly necessary has been done oftentimes to superfluity. This full supply of economic tools to meet the wants of nearly all branches of commerce and industry is the most important factor in the present industrial depression. It is true that the discovery of new processes of manufacture will undoubtedly continue, and this will act as an ameliorating influence, but it will not leave room for a marked extension, such as has been witnessed during the last fifty years, or afford a remunerative employment of the vast amount of capital which has been created during that period. The market price of products will continue low,

> no matter what the cost of production may be. The day of large profits is probably past. There may be room for further intensive, but not extensive, development of industry in the present area of civilization.

Note the suggestion of technological unemployment and note that the day of large profits is probably past, or so he says.

Any one of these quotations could be read almost without the change of a word to describe the present situation, and these are only a few of the quotations that are available. Any number can be gotten together of the same general type.

It is particularly interesting, I think, to engineers, in connection with this depression, that, while Wright in his report of 1886 hints more or less at the responsibility of the scientist, the engineer, the chemist and others for the depression, that is, for the creating of technological unemployment, the current depression is really the first for which scientists and engineers have been generally blamed. Not only have we had to stand our share of the grief of the depression, but, adding insult to injury, we and those who are applying science to the uses of mankind are blamed for the depression.

Let me state very briefly what in my judgment it is clear that the scientist, the engineer and the others applying science to the uses of mankind have done for the world. We have freed the world from the physical menace of famine. We have raised the general standards of living. We have supplied mankind with increased leisure. We have provided new means and opportunities for education, entertainment and amusement. We have relieved man of much of the drudgery of labor. These have been great achievements, and I do not have to ask this group whether this is all over. We know as to our own industries that progress has not ended. We know there are going to be new industries, the nature of which we do not conceive of at the present time any more than Wright could see clearly ahead in 1886 when he practically said that about everything that was worth while doing had been done and that there was not much more to do.

At that time the telephone was ten years old and had but little commercial development. He never thought that it would develop to the point where it would furnish employment to about one per cent of the total working population of this country. The automobile, of course, was not in the picture at all. Electric light and power distribution were scientific toys. The moving picture had not started its career. In fact, all of us can think of a hundred and one things which were not available in 1886 and which are important parts of our social and economic life today, and which furnish employment to millions.

I believe that if we were to put ourselves on record as saying that fifty years from now there would not be much of anything of importance except those things which we know of today, you gentlemen can figure as well as I can what such a record would look like then. Somebody might be getting up at a dinner like this fifty years from now and quote such a statement as being an amusing illustration of shortsightedness.

It seems to me that it is clear from reading past economic history that every severe depression is accompanied by certain assumptions by the people of the time. In the judgment of current observers, each depression is regarded as being more severe than those which came before. It is assumed to be of novel character and to have deep-seated causes which either cannot be removed at all or which can only be removed by revolutionary changes. Such a period of depression always gives rise to all kinds of proposals and suggested cures. Some of these, especially those the least fundamental in character, prove to be worthy of serious consideration and trial. Many, subsequent events show, can only be classed as foolish or fantastic. In the past, notwithstanding that the panaceas which were recommended as being the only cure of the then current depression were not adopted, the depression ended just the same and industry went on to higher levels.

From what I am saying, I do not wish you to think that I am belittling the seriousness of the existing situation. It is serious. It is deplorable. All of the things which are being done to help the situation should be continued and perhaps others will be necessary. History, however, indicates that we do not necessarily need fudamental changes. Certain symptoms need treatment. There are evolutionary changes going on all of the time. These should be continued. If other things are thought of which it is clear will be helpful, they should be done. But the past tells us that there is no use in looking around for a Moses to lead us out of our troubles. We don't get out of depressions by the leadership of Moses. There is no use of looking for a grand and comprehensive plan which will fix everything. We all contributed to getting into our present difficulties and we must all contribute to getting out of them. This process has successfully brought us out of previous depressions.

We engineers may, I believe, congratulate ourselves on the contributions that we have made to civilization. The problems of this era are not the problems of the past. Economic history tells us that up to a period of, say, one hundred years ago, the problems of the world were problems of want as well as the problems of distribution. The methods of production did not permit of creating enough to enable more than a very small number of the inhabitants of the world to live on any basis above a bare level of sustenance. Our problem today is only a part of the former problem and should be a simpler one. It is not the problem that we haven't got and can't get the things necessary to give us a higher economic level. It is the problem of the distribution of plenty. The problem that must be solved now is not the problem of how to create enough to keep the bulk of the people of this country above the level of want. Our problem is, having the ability to produce it, how to distribute it to the population. This change in the social problem is the major contribution to the world of the scientist and those who have worked on the application of science, the engineer and others.

In closing may I again quote from what Macaulay said in 1830:

> We cannot absolutely prove that those are in error who tell us that society has reached the turning point—that we have seen our best days—but so said all who came before us and with just as much apparent reason.

I firmly believe that the future holds in store for us engineers opportunities at least as great as, if not greater than, any that we have had in the past.

BANCROFT GHERARDI

Improvements in Telephone Service

"THE fact that the responsibility for such a large part of the entire telephone service of the country rests solely upon this Company and its Associated Companies . . . imposes on the management an unusual obligation to the public to see to it that the service shall at all times be adequate, dependable and satisfactory to the user." It is the aim "to make it possible for anybody anywhere to pick up a telephone and talk to anyone else, anywhere else, clearly, quickly and at reasonable cost."

With this idea in mind the effort is made to obtain the best possible results in providing, at reasonable cost, a service which is of high technical quality and is satisfactory from the viewpoint of the user. In recent years many important service improvements have been effected. Some of these have been noted in the Annual Reports of the American Company. It should be of interest to take a closer view of these betterments, to consider their significance and some of the processes which have been instrumental in bringing them about. First, however, it should be recognized that public satisfaction is dependent not only on high grade service but also on favorable general attitude toward the company, its personnel, its acts and policies. Two examples may be cited of factors exerting a favorable influence on public opinion. Certainly Mr. Gifford's "Statement of System Policy" made at Dallas in 1927, which is quoted above, has served to increase understanding and favor of System policies and practices. In the day to day operation of the business one of the best opportunities for building favorable impression lies in the many contacts between representatives of the company and the public which it serves. These contacts may involve matters of publicity or public relations; they may have to do with problems of business development, right-of-way or construction; they arise in connection with the installation, maintenance and repair service and in connection with the handling of telephone calls; they take place in the business offices regarding such matters as arrangements for service, collections and requests for miscellaneous information. Much has been done and is being done to insure that employees handle these contacts in a manner that the public will consider both pleasing and helpful.

Having made his arrangements for service at the business office or through the employee selling plan, the customer's first impression of the company's performance is usually obtained from the time required to install the necessary apparatus on his premises and to make the service available for use. This interval, which now averages about two and a half days for the System as a whole, has been subject to constant improvement for many years; it was nearly five days on the average in 1925. The so-called "appointment plan" has been a valuable aid in obtaining this result. By this plan an appointment is made with the customer at the time his order is taken as to when the work on his premises will be done. This gives the customer an opportunity to express his preference as to a convenient time and, in the large majority of cases, the work is scheduled in accordance with his suggestion. In the larger cities over 95 per cent of the installation orders are now handled on this basis and the installation forces are meeting the appointment times on about 97 per cent.

The giving of high grade service makes it essential that telephone lines and equipment be kept as free as possible from service failures and interruptions and that such troubles as do occur be cleared promptly. Troubles in telephone plant, which are indicated by the number of subscriber reports per 100 stations, have been nearly halved since 1925. Expressed in terms of frequency, some kind of trouble now occurs on the average subscriber's line or station once in every twenty-four months as compared with once in every thirteen months seven years ago. Improvement has also been made in the time taken to effect repairs. Ninety-three per cent of all out of service troubles are now cleared on the day on which the trouble is reported—85 per cent being so cleared in 1925. A large majority of these troubles are cleared within a few hours from the time of the report.

Preventive work which aims at locating and correcting line and equipment faults before service impairment occurs has assumed an increasing importance in the maintenance program. Improved methods of recording and classifying troubles have provided those responsible for the maintenance of plant with better information on which to base their operations. Study and analysis of the causes of trouble, particularly those of a recurring nature, have resulted in improved design and in better maintenance practices. More adequate testing and inspection have contributed to the general improvements. Testing is not only more complete than formerly but is now done with improved devices designed to facilitate the finding of faults previously difficult to detect. The volume of inspection has been increased by sampling checks made by supervisors on the work performed by the forces. The checking of the condition of equipment on locations visited by installers, repairmen, cable splicers and linemen on specific jobs has increased the effectiveness of the preventive work.

The local exchange service of the Bell System involves the handling of some 75,000,000 calls a day, of which about 45,000,000 are handled manually and the remainder through dial equipments. In manual service three features stand out as major considerations. The importance of prompt answers to subscribers' signals lies in the indication thus given of the alert availability of telephone communication—the readiness to serve. Service accuracy, which is measured by the degree with which it is found possible to avoid wrong numbers, cutoffs and other interruptions to telephone conversations, carries large weight in the pubic estimate of the service as a whole. The immediate establishment of a high percentage of connections is, from its very nature, a fundamental requirement under both manual and dial operation. During the last ten years answers to line signals slower than ten seconds have been reduced by 25 per cent, service inaccuracies have been lessened by 50 per cent and calls failing of immediate completion by nearly 20 per cent. If we relate these betterments to the large annual volume of exchange traffic, we find that there are 125,000,000 fewer calls with answers slower than 10 seconds, 125,000,000 fewer calls with service inaccuracies and about 1,000,000,000 more calls with immediate completion. A decrease, in recent years, of more than 50 per cent in subscribers' criticisms regarding these matters indicates a gratifying degree of public appreciation.

There are a few major considerations regarding these features of local service that will indicate the course pursued in their improvement. Ninety-seven per cent of the line signals are now being answered within 10 seconds and the average answer is about 3.5 seconds. This answering service appears to be quite satisfactory to users. The problem is largely one of obtaining as much uniformity as possible from day to day and from hour to hour. Closer adjustment of the forces to varying traffic volumes, with special attention to odd hours when manual switchboards must be operated by reduced forces, better operating performance, particularly as regards expeditious handling and teamwork, and improved equipment arrangements are some of the more important factors in the improved results.

Service accuracy is affected both by telephone company faults and by mistakes made by users; at the present time the inaccuracies resulting from each of these causes are running about 1 per cent. The betterments previously noted relate to those inaccuracies for which the company is wholly or partially responsible. To a large extent, inaccuracies caused by users result from calling a number which is not the number really desired. The telephone company undertakes to provide every subscriber with an up-to-date directory, and emphasizes the importance of using correct numbers, but the inaccuracies from this source remain fairly constant.

Inaccuracies resulting from company faults occur with different frequency in exchanges of different size, being lower in the smaller places, where the operator receiving the call establishes the connection directly at her own switchboard, and higher in the large cities, where all or nearly all calls require inter-office trunking, a procedure which involves two and in some cases three operators and switchboards. Recent years have seen the development and effective use of new operating practices and supervisory routines aimed at more accurate service. Improved equipment arrangements and better maintenance have contributed to the same end. The attention given to clear enunciation and voice technique, both in the selection of operating employees and in their training, has been an important factor in minimizing uncertainties and misunderstandings between operators. In the large cities, wrong numbers have been reduced radically by the introduction of an improved trunking method, known as straightforward trunking, by which the operator at the calling office selects an idle trunk to the called office over which the call is passed and the connection established. Under the former trunking plan, orders for numbers were passed and trunk assignments obtained over a call wire used in common by many operators.

While the percentage of calls completed immediately is found to be the most practicable measure of the effectiveness of the local service, it should be understood that the majority of calls failing of immediate completion are completed later. During the last ten years there has been an increase in immediate completion from 78 per cent to 82 per cent. Recent improvements in accuracy and in the general quality of the operating work have had a favorable effect on the completion results. However, most calls which fail of immediate completion fail either because the called line is busy or because no one answers at the called telephone. The busy line situation has been improved by general emphasis on the importance of adequate telephone facilities for subscribers with relatively high usage requirements. The majority of "don't answer" conditions involve cases where there is no one on the subscriber's premises to answer the telephone. But measurable reductions in these occurrences have been effected by bringing to light the need for supplementing or relocating bell equipment so that rings can be heard throughout the premises, for relocating instruments or adding an extension station so that calls can be more quickly and conveniently answered.

In recent years advances of outstanding importance have been made in the handling of toll and long distance service. Better equipment and switching arrangements and improved transmission have removed the previous limitations to good wire communication. The development of radio telephony has resulted in the introduction and extension of intercontinental services and ship-to-shore services; over 90 per cent of the world's telephones can now be reached by Bell System subscribers. Marked improvements have been made in the speed and quality of service.

About 70 per cent of the toll business, including large volumes of short haul traffic around the metropolitan centers, is now handled at local switchboards along with exchange calls and, with the exception of the requirement for ticketing, by the same operating procedures. Over 10 per cent of the total toll business of the System has been given the service advantages of local board operation during the last ten years as a result of the development of new equipment arrangements and methods which have made possible a wider application of this plan.

Service on the longer haul traffic, which is handled at toll boards, has been radically improved both as regards speed and kind by the introduction of a new plan of toll board operation. The speed of service, which is measured by the interval from the receipt of the signal at the toll board till subscribers start their conversation or are given a definite report of delay in reaching the called party or telephone, now averages about one and one-half minutes as compared with nine minutes ten years ago. The type of service now simulates that on exchange traffic, over 90 per cent of toll board calls being handled immediately they are placed and while the customer remains at the telephone. Under the previous operating plan, calls were recorded by a special group of operators and customers were requested to hang up their receivers as soon as this had been done; calls were handled by another operator group located at switchboards equipped for this operation and customers were recalled when the connection was ready. While improvements were made with this method, there were fundamental limitations as regards speed which do not exist in the new plan which combines the recording and handling functions. The new plan has brought new possibilities for betterments in technical operating, the realization of which has allowed of continued service refinement.

Unsatisfactory transmission, cut-offs and other interruptions to subscribers' conversations have been reduced by two-thirds since 1925; over 98 per cent of the toll board calls are now free from these faults. This result is the more significant for the reason that the expansion of the system and, more particularly, the increase in usage involving longer distances and localities off the main traffic routes, have added to the difficulties. Several factors have contributed to the improved results: better records of unsatisfactory occurrences and effective action based on careful analysis of these records; improved design and better maintenance; special treatment of routes shown to experience an unusual amount of trouble; better route selection for traffic requiring switching, with special operating practices on the more difficult business; adoption of a system-wide toll switching plan which minimizes the amount of switching and provides high grade facilities between key points.

Over 91 per cent of toll board calls are now being completed. In the last ten years the percentage of uncompleted calls has been reduced by nearly one-third, even though during this period large volumes of business with high completion possibilities have been transferred to local board operation. These completion figures relate to the final disposition of calls. Toll board traffic includes not only calls for numbers, which is the characteristic of local service, but also calls for particular persons. The requirement for reaching a particular person increases the chance for completion failure, as in many cases persons are reached only after several efforts on the part of the operator and in some cases they cannot be reached at all. Completion improvement has been brought about largely by the development of improved practices and more thorough treatment of calls encountering delay. In the latter work it is necessary to maintain a satisfactory balance between increased completion and unfavorable public reaction to over-attention or over-persistence on individual calls.

Dial operation has become a major factor in service progress; approximately 5,500,000 telephones are now being operated on this basis. The introduction of the dial system, which has been going on since 1921, is a part of the general plan to keep the design and improvement of switching systems in line with service requirements as indicated by long range estimates. Experience through periods of rapid growth has shown clearly that, in the long run, it would be difficult and expensive to meet future demands for telephone communication and to continue to improve service relying entirely on manual operation. Dial service and manual service are different in detail but, in both, speed and accuracy are considerations of first importance. Dial service is faster and more accurate than manual. Furthermore, with the dial there is less variation in the speed of connection, and, due to the fact that full operating facilities are available at all times, the dial service has a distinct advantage at night, on Sundays and at other times when manual switchboards must be operated with largely reduced forces. The handling through the machine of large volumes of traffic susceptible to this treatment allows a concentration of the manual effort on that part of the service which offers the greatest opportunity for improvement through personalized attention to individual calls. For the toll service, for special services and for other manual operations supplementing the dial, there are requirements for large numbers of operating employees.

Private branch exchange operation has a large bearing on service results and on the problem of effecting improvements. Approximately one-fifth of the telephones connected to the Bell System receive service through these private boards, in the operation of which subscribers employ nearly 100,000 operators. In many of the large cities 50 per cent of the traffic goes through at least one private branch board. A local call between telephones connected to different private boards involves twice as many operators and twice as many connecting points as a call between two telephones connected directly to the central office. The telephone companies carry on a number of activities which are designed to assist subscribers with private branch boards in obtaining a satisfactory grade of service and these activities have been instrumental in effecting improvements. The companies maintain specially trained groups for rendering this assistance. They hold themselves in readiness to supply competent operators either for permanent or temporary employment. They provide school facilities for the initial training or retraining of subscribers' employees.

Service betterments of the kind that have been referred to provide concrete expressions of the effectiveness of the work of many groups in the Bell System organization—research experts charged with developing improved equipment arrangements for central offices, outside plant and subscribers' stations—engineers responsible for plans that assure the proper amounts of the right type of equipment being in the right place at the right time—factory, construction and installation forces who carry out these plans for additions and betterments in the physical plant—staff groups both in the Associated Companies and at 195 Broadway working on improved service arrangements, operating and engineering practices and supervisory processes—maintenance men who keep the apparatus in condition for service—and the operators at telephone switchboards.

M. B. French

We Fight a Sleet Storm

TWO hundred communities in North Dakota found themselves back in comparatively primitive modes of living for a few days in October. Kerosene lamps were dug out of attics and strove vainly to take the place of electric lights; radios stood silent; electric refrigerators "defrosted" and stood warm and useless, horse rigs supplanted automobiles—and the telephone in many cases was voiceless.

A sleet and snow storm had paralyzed transportation, electric power transmission and communication. About 50,000 of the 70,000 square miles in North Dakota were affected by the storm, the communities in the sleet area suffering damage in varying degrees.

A drizzling rain which began to fall on October 18 turned into ice and snow as the day became colder. Throughout the following night the icy drizzle continued until precipitation aggregated more than an inch. The temperature dropped slightly below the freezing point turning the rain into ice wherever it fell. This icy coating is sleet, also called "glaze." A northwest wind reaching velocities of 24 to 31 miles an hour completed the triangle of forces—rain, freezing temperature and wind—which wrought havoc. Wires, poles, trees, signs and other things which might have withstood the burden of ice were unable to withstand the combination of ice and wind.

The sleet area extended from Colorado in the United States to Manitoba in Canada but the damage was slight except in North Dakota.

Snow followed the sleet, particularly in the Black Hills of South Dakota and in North Dakota, and the heavy wind whipped up snow banks which stopped or seriously handicapped highway and even railroad travel. A train was stuck in a snow-filled cut near Max, North Dakota. The train crew, helped by willing passengers, dug a path through the snow but it filled up again in an hour. A railroad snow plow was sent to the rescue but failed to reach the marooned train in its first attempt.

Telephone, telegraph and power lines suffered most severely. The ice on wires was from one inch to an inch and a half in diameter. At the peak of the trouble a total of 199 communities were isolated so far as long distance communication with the outside world was concerned. Of these, 58 were exchanges of the Northwestern Bell Telephone Company and 141 were toll points and connecting company exchanges. A total of 12,858 telephone poles were down, of which 11,000 were long distance poles of the Northwestern Company. A total of 2,275 miles of the Associated Company's long distance wires were damaged. Telephone lines running parallel with the direction of the storm generally remained intact, while the lines which were struck broadside were unable to withstand the terrific strain of the wind against the load of ice.

Among businesses which were handicapped both by the lack of power service and communication service were newspapers. Long distance lines and special circuits which carry news from neighboring communities and from faraway parts of the world were crippled. Even if the news could have been obtained there was no electric power to run their linotype machines or their presses. Some newspapers came out several days late on presses run by improvised gasoline engines and in type set partly by hand.

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Sleet is the greatest physical hazard with which the telephone industry in this country has had to contend. Hurricanes may visit portions of the country, cyclones may rip across prairies, and fires and floods may inflict damage but all of these hazards are secondary compared with the vast damage which sleet accompanied by wind may inflict on telephone wires within a few hours. The weight of sleet clinging to wires at a temperature hovering around the freezing point, and with a wind blowing, will tear down telephone lines which raging snowstorms and sub-zero weather may not harm at all.

When a sleet storm appears, the first step in restoring telephone service is to get reports to plant headquarters of the extent of damage so that the head of that department can mobilize men and materials. Just as soon as the sleet started to cling to wires plant men in the area affected went out to patrol the lines and to estimate the damage.

Since practically all means of communication and transportation were down, the job of getting estimates of the damage into district headquarters and into Fargo, headquarters for the North Dakota area of the Northwestern Bell Telephone Company, was extremely difficult. The use of airplanes was considered but the storm continued so long and visibility was so poor that it was impossible to use this modern method of quick inspection.

In spite of obstacles, reports were gotten into Fargo by various means. The traffic department helped to "build up" circuit in roundabout ways, going hundreds and even thousands of miles to get around a gap in toll lines. Reports were also brought to strategic points in person and by mail.

Local radio stations co-operated whole-heartedly in the efforts of the telephone company to restore service. Among these was station KFYR at Bismarck, capital of the State, which was directly in the path of the worst sleet. In the emergency, radio was used both to make reports from the stricken area to Fargo and from Fargo to the crews at work in the field. Messages were broadcast asking individuals who might hear them to take them to certain offices or certain foremen. Scores of people heard the messages and transmitted them to their destination.

At Fargo, area headquarters, maps were placed on the walls of the offices of the plant manager and the construction superintendent. These maps showed the extent of damage and later the rate of restoration. The reports covered the number of toll poles down, the amount of toll wire down, the damage to exchange plant, the number of exchanges isolated, the number of stations out of service, the damage to connecting companies, and conditions in general.

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With estimates of the damage pouring in, the plant manager was able to organize his forces to combat the sleet. Just as soon as the plant men in the various communities had reported the extent of the damage they went to work making repairs. These first repairs were principally efforts to restore service within towns.

Reports quickly indicated that the comparatively small construction forces of the North Dakota area would be unable to cope with the situation. Calls for help were sent immediately to the Minnesota and the Iowa areas of the Northwestern Bell company. Within a short time it became apparent that still more assistance would be required and calls for more crews were sent to the Nebraska–South Dakota area of the company and to the Long Lines department of the American Telephone and Telegraph Company. Crews which were on routine work in the other areas dropped the jobs before them and soon their trucks were rumbling over the highways toward the scene of the disaster in the north. Within a few hours after getting the calls, 12 crews were on their way from Iowa, 10 from Minnesota and 4 from Nebraska–South Dakota. Three Long Lines crews also headed for North Dakota.

All incoming crews were asked to bring their own telephone trucks instead of coming by train and taking a chance on renting commercial trucks in the territory where they were to work. It is not always possible to rent trucks in small communities, and even when it is possible, the ordinary trucks are good only for transportation and hauling purposes, while telephone company trucks are equipped with pole setters, winches and other equipment which expedite construction work. By using their own trucks, crews from other states arrived on the scene quickly, were protected against the elements by the tarpaulin coverings, were able to bring tools and equipment, and could restore service faster. The plan of having borrowed crews bring their own trucks worked out very satisfactorily.

Probably the longest trip was that of a foreman who was working at Oxford, Nebraska, near the Kansas line. The call from Fargo came at 9 o'clock at night and by 11 o'clock the foreman and two men were started on the 250-mile drive from Oxford to Omaha. They drove all night and arrived shortly after noon, picked up four more men who were waiting in Omaha, laid in a stock of tools and equipment and started for Grand Forks, North Dakota, at 3 o'clock. The drive from Omaha to Grand Forks was nearly 600 miles and from Grand Forks they still had about 100 miles to go, making a total of about 1,000 miles from their starting point.

While crews were coming in, the construction superintendent planned his attack on the enemy. Seven supervisory foremen were assigned to strategic points in the sleet area. These were the tireless field generals who directed the work of a total of 40 foremen and their crews.

In restoration work in North Dakota local men were hired for the work of groundmen and tasks which did not require technical telephone knowledge or experience. This plan saved the transporting of such men hundreds of miles. It also meant the hiring of residents in small communities and on farms in a period of unemployment when local residents were glad to find work. When a crew moved from one town to the next new men were hired at the community at which it arrived thereby spreading employment over the entire sleet area.

While plant forces naturally bore the brunt of work in the sleet emergency, employees of all other departments also took part.

Mobilization of men is only one part of an offensive against sleet. Just as soldiers in war need ammunition so storm repairmen need materials. Poles, crossarms, wires and other material in local supply yards were quickly exhausted but thanks to the co-operation of the Western Electric Company and modern methods of transportation a steady stream of supplies kept coming in to the crews. This problem of materials is no small part of the generalship of combating a storm. Sometimes the problem of materials is the biggest one.

In the North Dakota case the Western Electric Company shipped supplies from its warehouse in Minneapolis and in turn replenished its stock from the warehouses at Omaha and Des Moines and from its plant at Hawthorne near Chicago. Economy of transportation of poles was effected by shipping them directly from the pole yards of suppliers in Spokane and other points in the northwest. A total of 4,374 poles, 8,000 insulators, 1,500 crossarms and a large number of miscellaneous supplies were shipped in.

The advantage of standardization of equipment, training and methods in the Bell System was strikingly demonstrated in the mobilization of men and material to fight the sleet storm. Men who were rushed from surrounding states found equipment and tools like those to which they were accustomed at home; they worked effectively with plant men whom they had never seen before as their training methods had been about the same.

The value of the services of the Western Electric Company to the Bell System likewise was shown. Instead of there being a wild scurry to get poles, wire and other supplies, a steady stream of materials was set in motion with a minimum of effort, and the construction men who valiantly were working to restore service felt assured that from the reserves of the Western Electric they would have materials with which to work.

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Restoration work was divided into three phases. First efforts were to get up important lines just as quickly as possible to restore inter-city communication to all towns in the shortest possible time. In some cases one line was put through and all towns hooked up to that one long distance line just as farmers get service over one pair of wires. The term plant men use for this first restoration is " to jury up " a line.

The problem in this first restoration or " jurying up " is to restore the pole line to carry circuits temporarily, without the delay required to set new poles, replace damaged crossarms and do other work. In order to do this, crossarms are bolted to stumps of poles, top sections of poles are set into the ground, poles broken at the ground line are reset—anything to get service re-established. Customary clearances of wires above ground are disregarded except over highways, railroads or wherever injury might result.

Following the " jurying up " of shattered lines, the second step in restoration was made. The second phase consisted of restoring practically all service. Where damage to poles and wires was small, complete repairs were made, but where the damage was severe only temporary repairs were made. A second sleet storm four days after the first storm tore down again some of the repaired lines in the vicinity of Minot.

The third step is the final restoration of all telephone plant which fell before the attack of the sleet. Some of this work was halted when frost prevented working in the ground and will not be completed until the spring of 1933.

All wires of the fourteen circuits of the transcontinental line into Bismarck from the East were broken, but service into Bismarck, including a radio program supply circuit, was restored the day after the storm. The ten circuits of the transcontinental line west of Bismarck to Dickinson likewise were severed by the sleet. Although the wire was badly damaged, service was restored in five days.

Handicaps which confronted construction crews included snowdrifts, which sometimes prevented the use of trucks and necessitated the substitution of horses and wagons; bad side roads where there was no pavement or gravel; inclement weather; and limited housing and feeding accommodations because towns were so small. Another handicap was the fact that of the lines which were down, 1,500 miles were along railroad right-of-way and were not easily accessible with trucks.

Crews worked from daylight to darkness, driving in from the job after darkness had settled down. One crew got stuck in the snow on the way home and worked until midnight extricating itself. Even after they arrived at their rooms after 12 hours or more in the field, the day was not over for foremen and other supervisors, for they had reports to file of the day's work and plans to make for the day to come.

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The restoration of lines was not done in a haphazard manner. While construction men were in the field laboring with poles and wires, engineers pored over blue prints and were out on trips of inspection determining what facilities should be restored first and making plans for permanent restoration. Often telephone plant is rebuilt on a different basis than the original. Growth or other conditions may have made changes advisable. For instance, in the town of Edmore the telephone plant was badly damaged. Instead of restringing wire on poles, engineers decided that it would be better to install an entire new system of cable. The proper sizes of cable were rushed to the scene by the Western Electric Company and installed at once to serve the town.

Traffic engineers also had engineering work to do in determining what circuits were most essential in preliminary restoration work and also what circuits will be required for future use in accordance with their studies of telephone traffic in the territory.

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Why this quick mobilizing of men and material, why working hours from daybreak to dark, why the working in spite of obstacles and hardships?

It is because of the recognition by everyone in the telephone business that telephone service is vital to communities and to individuals. Every telephone worker did everything possible to meet the needs of customers.

Long distance calls of an urgent nature were handled by circuitous routes. For instance, Minot was not isolated from the North and West and calls which ordinarily would cross the state from Minot to Fargo, a distance of a little over 200 miles, were handled in some cases by way of Fargo, Winnipeg, Calgary, back to Regina and down to Minot, a distance of 1,750 miles. Likewise, calls from Fargo to Williston and Dickinson went all the way around by Minneapolis, Chicago, Denver, to Billings, Montana, and into North Dakota from the West. This roundabout way was a thousand miles longer than the route through Canada. One urgent call from Winner to Rapid City, South Dakota, less than 100 miles away, was switched around by way of Norfolk, Nebraska, Omaha, Denver, Casper, Wyoming, and then into the Black Hills from the West, a distance of 1,700 miles.

The long distance service of the Bell System is affected when a sleet storm cuts all lines in any locality and leaves a blank spot in the network of the System. But the Long Lines department of the System is ready to meet such emergencies by means of "traffic control bureaus," organized for just that purpose.

When reports of the failure of lines in North Dakota began to come in, the Long Lines control bureau in Chicago immediately began to rearrange circuits, pooling the facilities of the American Telephone and Telegraph Company with those of Associated Companies of the Bell System. The control bureau established "patches" around the break section.

The circuit between Chicago and Helena, Montana, which normally would go over the northern transcontinental route, was established via Salt Lake City, using lines of the Mountain States Telephone and Telegraph Company north to Butte, Montana. The Chicago-Seattle circuit used the same route.

Minneapolis-Helena circuits were routed to Chicago and then by the Salt Lake way. Circuits from Chicago to Portland, Oregon, went around by way of San Francisco, using facilities of the Pacific Telephone and Telegraph Company.

Believing that telephone customers should know what was being done to restore service to them, advertisements were used in newspapers telling of the extent of the damage and the progress of the work of reopening communication. Similar information was contained in an insert sent with telephone bills to customers. Newspapers were kept informed and given all facts about the damage and reconstruction work. That the public appreciated the difficulties which faced the telephone company in restoring service and the heroic efforts of telephone employees was evident from numerous word-of-mouth commendations, letters and newspaper comments.

The following is an editorial which appeared in the Fargo Forum:

> Just a pleasant jangling of nickels in coin receivers, a slitting of envelopes containing fat checks—that's the version many have of the telephone business.
>
> But consider the Northwestern Bell Telephone Company and the recent series of sleet and snowstorms in North Dakota. It must expend more than $250,000 to repair damage caused by the dislodging of thousands of poles, the snapping and snarling of many miles of wires. While heroic deeds are being performed in biting cold by hundreds of linemen, its office personnel must answer pacifically an irate public which cannot understand why a long distance call cannot be completed through an area where poles are down and lines are broken.
>
> Add to this the heavy loss in revenue through curtailment of long distance facilities plus the practice of rebating for any period of lack of service for 24 hours or more.

The following story in the Daily News of Minot is an example of the perseverance of telephone men in their efforts to restore service:

> Because a Minot man, nearly tired out, plowed through snowbanks and groped in the darkness last night, subscribers of The News today are

enabled to read State and world news from the Associated Press in this issue.

Somewhere west of Minot, the wire over which the Associated Press dispatches are sent to The News from the St. Paul offices, went " open " yesterday. This has been a temporary and roundabout circuit from St. Paul to Chicago, Salt Lake City, Helena, Glendive, Williston and thence to Minot, instead of the usual direct line from St. Paul to Minot, which has been out of order for several days, due to storms.

Kenneth Rauk, Minot, lineman for the Northwestern Bell Telephone Company, came from Granville to Minot yesterday forenoon, nearly six hours being required for the 24-mile journey. Instruments in the Minot offices indicated the wire break was somewhere near Manitou, in western Mountrail county, and Rauk and helpers were sent out to find it.

Late last evening Rauk called from Stanley; he and his helpers, Maynard Peterson and Harry Manternach, were very tired. Did the line have to be fixed last night?

" It means no Associated Press news for Daily News readers unless it is," Charles Keith, wire chief in Minot, told him.

" All right, we'll find it and fix it," replied Rauk.

Near Manitou, about midnight, the workmen discovered the break. Other telephone poles and wires had fallen over the line and broken it. The electric lantern carried by the men went out, but they worked on with a flashlight, and the line was repaired.

And so today, over several thousand miles of wires, Associated Press dispatches clicked into The News office through the automatic telegraph printers, thanks to Lineman Rauk who didn't have to find the " break " last night but did.

SIGURD U. BERGH

EDITOR'S NOTE: Mr. Bergh's contribution is based on personal information which he gathered as editor of *The Northwestern Bell,* the employee's magazine of the Northwestern Bell Telephone Company.

The Service of Classified Telephone Directories

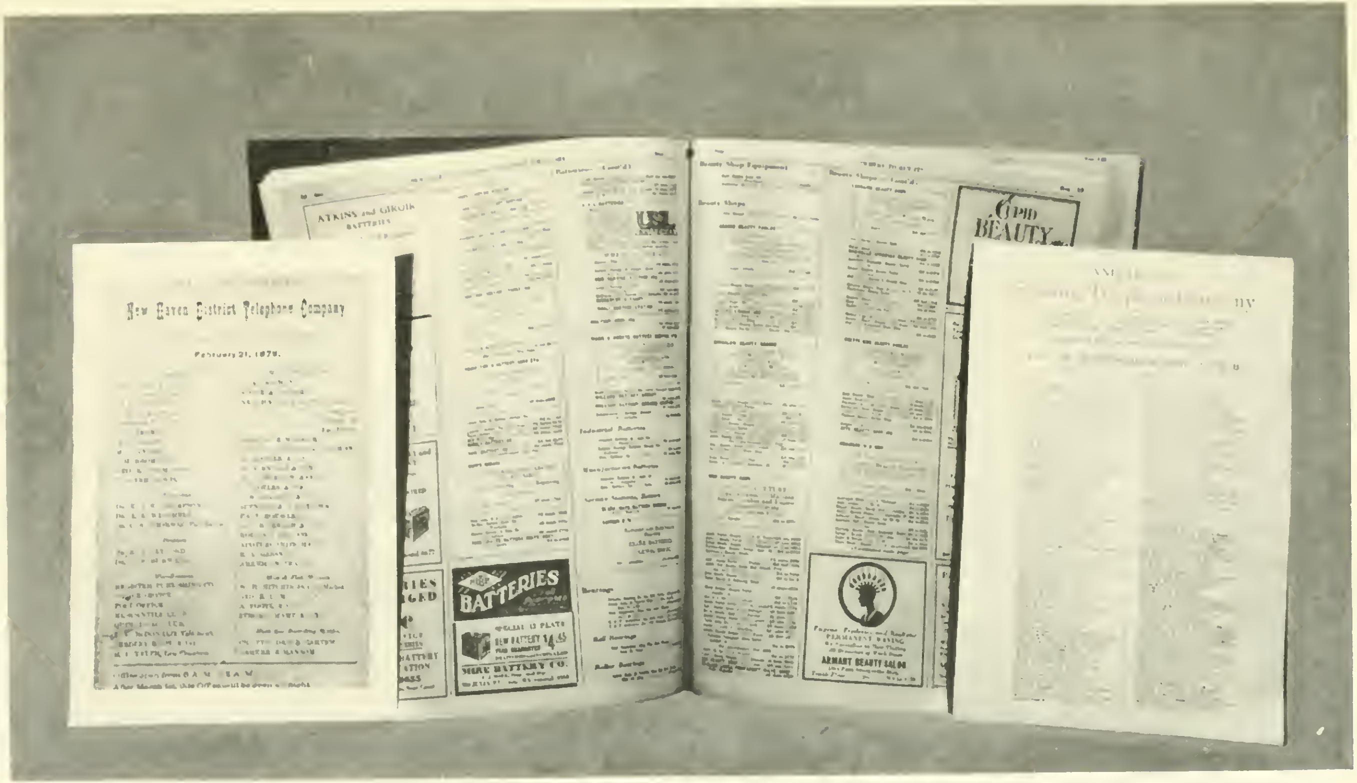
THE world's first commercial telephone exchange was opened for service in New Haven, Conn., on January 28, 1878, and on February 21 of the same year was issued the first telephone directory: "List of Subscribers, New Haven District Telephone Company." In less than a month it had become apparent that a directory of subscribers was a necessary adjunct to the rendering of telephone service.

This first directory was a small card containing fifty listings, and since subscribers were not listed in any alphabetical order but were grouped under headings such as "Residences," "Physicians," "Meat & Fish Markets," "Hack and Boarding Stables," etc., it may properly be called also the first classified telephone directory.

It was soon evident that, with a larger list, the arrangement of subscribers alphabetically was needed, and the second directory, issued in San Francisco on June 1 of 1878 with 178 listings, was the first to record its subscribers in that orderly fashion.

As the telephone grew in popularity throughout the country and the number of subscribers increased, with consequent increase in the number of listings in each directory, the opportunity was recognized to increase the usefulness of the directory service to subscribers by issuing, in addition to the alphabetical directories, lists of business subscribers grouped according to the businesses they were engaged in. The user of the telephone directory would find this supplementary list an additional convenience, and the value of telephone service to business concerns would be enhanced.

Beginning with a page or two, these classified lists of business subscribers have grown, along with the telephone business, to



Two Pages of a Current Classified Telephone Directory, Flanked by the New Haven and San Francisco Lists of 1878—the First and Second Telephone Directories in the World.

the highly developed and useful classified telephone directories of the present day. The cities of the United States have classified directories to the number of about 1,000, all of the large and medium-sized cities being represented and many of the smaller ones. The classified directory is bound under the same cover with the alphabetical directory, except in a few of the larger cities where they are published as separate volumes because of their bulk.

To make the classified directories of maximum use to business men and subscribers, improvements have been made from time to time, and beginning in 1926 a rather complete change was brought about. This included a new and better standard of typography, a better arrangement of the display advertising, and a revision of the classifications which made for greater ease of reference and completeness of the buying service. At the same time a new feature, known as Trade Mark Service, was introduced. This service is simple in form, in method of purchase, and in operation. As purchased by a manufacturer or other user, Trade Mark Service comprises the inclusion of the name of his product or service in the appropriate position in the columns of directories in the towns where he has dealers or representatives, followed by the name, address, and telephone number of each authorized dealer or representative. This makes it possible for a manufacturer or other purchaser of Trade Mark Service to direct readers of his national advertising to the local representative by a simple reference in each advertisement to the listing of his product or service in the classified directory. It also makes it possible for a prospective purchaser to locate readily the authorized local source of supply, instead of having to "shop around" to find who handles the desired product or service.

These improvements in the typographical appearance and arrangement of the classified directories, together with the introduction of Trade Mark Service, have made the directories of even greater convenience to the telephone user, and more productive to the business man who uses its columns to promote his business.

The usefulness of the classified directory has been advertised in national publications by the American Telephone and Telegraph Company, and locally by the Associated Bell Companies through newspaper space, direct mail, posters, and billboards. This publicity has pointed out the convenience of using the classified: its accessibility, completeness—all business telephone subscribers are classified—and the new feature of Trade Mark Service. As a result of this advertising, telephone users have been frequently reminded that each subscriber is provided with a complete catalog of the businesses of the community for his use and convenience.

The usefulness of the classified directory as a Buyers' Guide and a telephone service convenience, together with the publicity to familiarize the public with it, have resulted in the classified directory becoming one of the most used and most useful books in the community. The many unsolicited comments from business concerns who received orders and inquiries for their products and services as a result of their listings and advertising in the classified directories give an indication of the place these catalogs of business information hold in the communities they serve. Studies undertaken in a number of cities throughout the country also indicate that classified directories are used by large numbers of subscribers.

With this knowledge as a background, a survey of a typical medium-sized city was undertaken last year, to develop facts about the use of the classified directory and also a procedure which would facilitate surveys under similar conditions at other points.

Columbus, Ohio, with a population of about 300,000 and approximately 50,000 telephone subscribers, was selected for the test. Based on existing knowledge of the extent of classified directory use, it was determined that a sample of 700 residence subscribers and 250 business subscribers, selected at random, would give an accurate picture.

Consideration was next given to the method of interviewing subscribers. The three usual methods of canvassing—mail, telephone, and personal visit—were studied in the light of time and expense involved and expected accuracy of results. A telephone canvass was decided upon, since it permitted the most rapid and economical coverage and, for the type of information desired, included practically all of the advantages of the personal interview while not involving the time and expense.

Attention was then given to the type of questions to be asked. The survey was intended to indicate in general: (1) volume of use, (2) scope of use, (3) type of use. A questionnaire was developed which contained questions designed to secure such information.

The employees selected to canvass the subscribers were the directory advertising sales representatives. These men were, of course, familiar with all phases of the classified directories and in a good position to discuss intelligently any points raised by subscribers as a result of the questions asked. The experience was also expected to be valuable to them in their later sales contacts with business subscribers.

The days of the week and the hours of the day assigned for canvassing were also given consideration. In calling residences, it was expected that week-days from 9 to 11:30 and from 1 to 4:30 would offer the least inconvenience to housewives and necessitate fewer recalls to those not at home or engaged in household duties. In the case of business concerns, no calls were planned for the noon hour. No calls were planned for either business houses or residences on Saturday afternoons.

The results of the survey indicated that 90 per cent of the subscribers interviewed used the classified directory: 68 per cent occasionally, and 22 per cent frequently. While these figures are impressive, and indicate that the classified directory fills a real need in the community, probably the most striking fact brought out by the survey was that 60 per cent of the users gave specific instances of use, naming the classified headings to which they had referred. A total of 931 instances were cited, covering a range of 159 different classified headings.

A compilation of the classified headings most frequently referred to disclosed some interesting facts. Heading the list were *Plumbers,* with 89 references, followed by *Cleaners and Dyers,* with 72. There were 42 references to *Taxicabs,* while *Coal* was in demand with 39, in spite of the fact that the survey was made in September. Other classifications frequently mentioned were *Physicians, Laundries, Rug Cleaners, Beauty Parlors, Radio Service,* and *Electric Service,* in the order named. Seasonal influences undoubtedly were a factor in the classifications mentioned, *Awnings* and *Screens,* for example, being two which would probably be uppermost in the minds of subscribers during the early summer months, and *Furnaces* and *Weather-stripping* in the winter.

In answer to one of the questions asked in the survey, 72 per cent stated that they used the classified directory in preference to the alphabetical when seeking the telephone numbers of business subscribers. While it was known that the classified directory is consulted for the purpose of finding the telephone numbers of known business subscribers about whose initials or address there is some doubt, the frequency of such use as disclosed in the survey was greater than had been anticipated.

One of the questions asked was designed to determine the reason for the selection of a certain business concern when consulting the classified directory. An analysis of the answers to this question disclosed that 52 per cent were influenced to call businesses whose names were recognized when seen in the classified directory, 23 per cent made their selections on the basis of location, and 22 per cent were influenced in their selections by the wording of the advertisements in the classified directory.

The survey also disclosed a number of instances where subscribers referred to directory classifications in words different from that of the classified heading plan. This information is valuable because it indicates the wording which naturally occurs to subscribers and gives an opportunity for further study of the classifications in the directory, with the possibility of adding cross-reference headings or revising some of the present headings to conform more nearly with the habits of the telephone users.

One of the interesting features of the survey was the almost negligible number of subscribers who indicated any annoyance at being called to answer questions concerning the telephone directory. On the other hand, there were a number of instances of subscribers who seemed rather pleased that they had been selected. All business subscribers who were questioned were told that when the directory sales representative called, before the close of the next directory, he would be glad to show the results of the study, and a number expressed considerable interest in seeing the results.

Careful analysis of the results of the Columbus survey indicate (1) that the classified directory as at present constituted is meeting the needs of a large majority of subscribers, (2) that the telephone questionnaire plan of canvassing used was satisfactory, although the experiment pointed out the need for slight revisions in the questionnaire to insure greater accuracy, (3) that the "sample" of 950 subscribers was adequate to give an accurate picture of the usage habits of Columbus subscribers, (4) that studies now under way to revise and improve the classifications used in the directories should be continued as a means of increasing the value of the directory to both users and advertisers.

The continued development of the classified directory through surveys such as that conducted in Columbus is but one phase of the Bell System's constant endeavor to increase the usefulness of telephone service to the public.

J. F. Allen

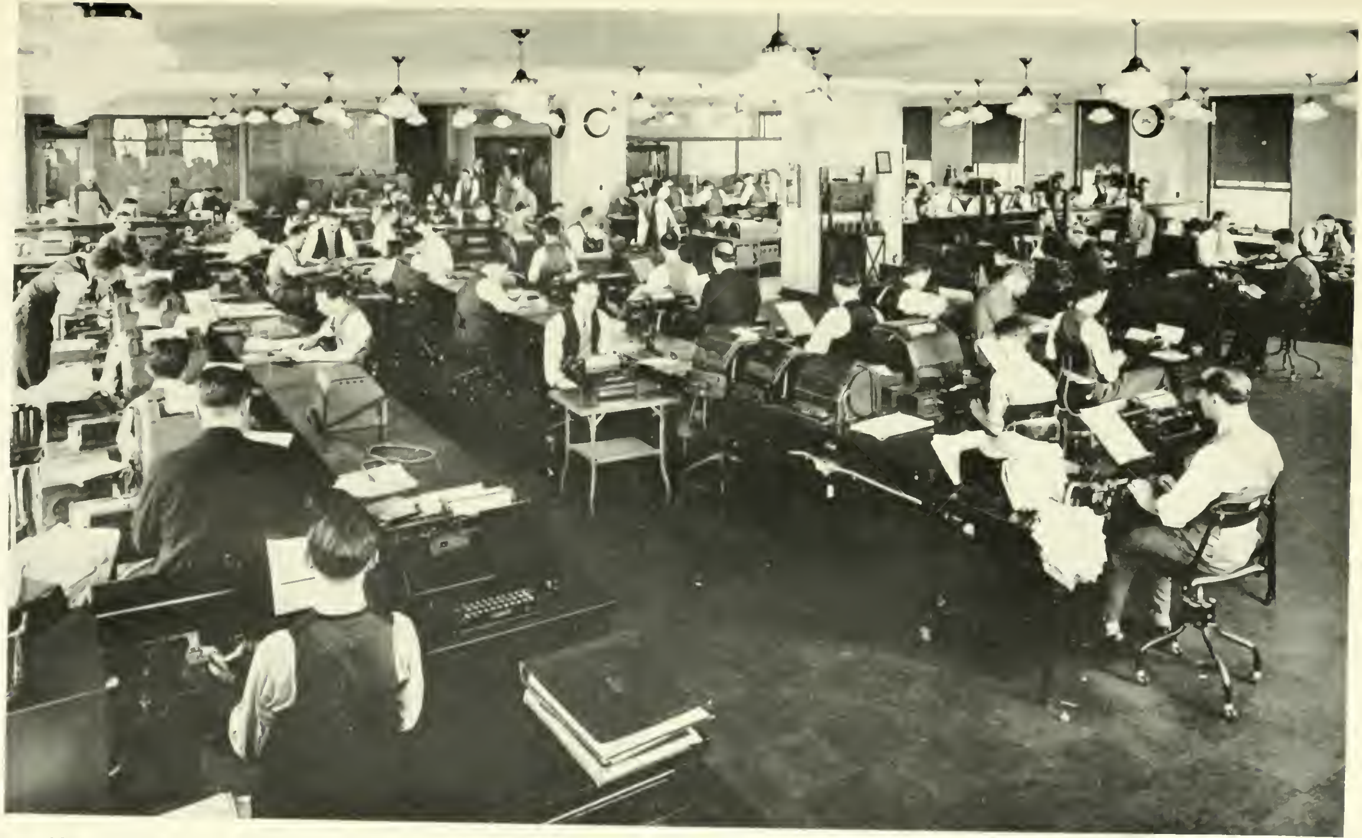
Elections and Communications

DURING the recent national political campaign and election, Bell System facilities were again extensively called upon to deliver the messages of the nominees for office, as well as the election results, to both the listening and the reading public. The program transmission systems of the broadcasting companies were busy almost nightly carrying the voices of speakers extolling their party platforms, and the leased wire systems of the press were equally busy reporting the text of the speeches, the public reaction and other interesting phases of the campaign.

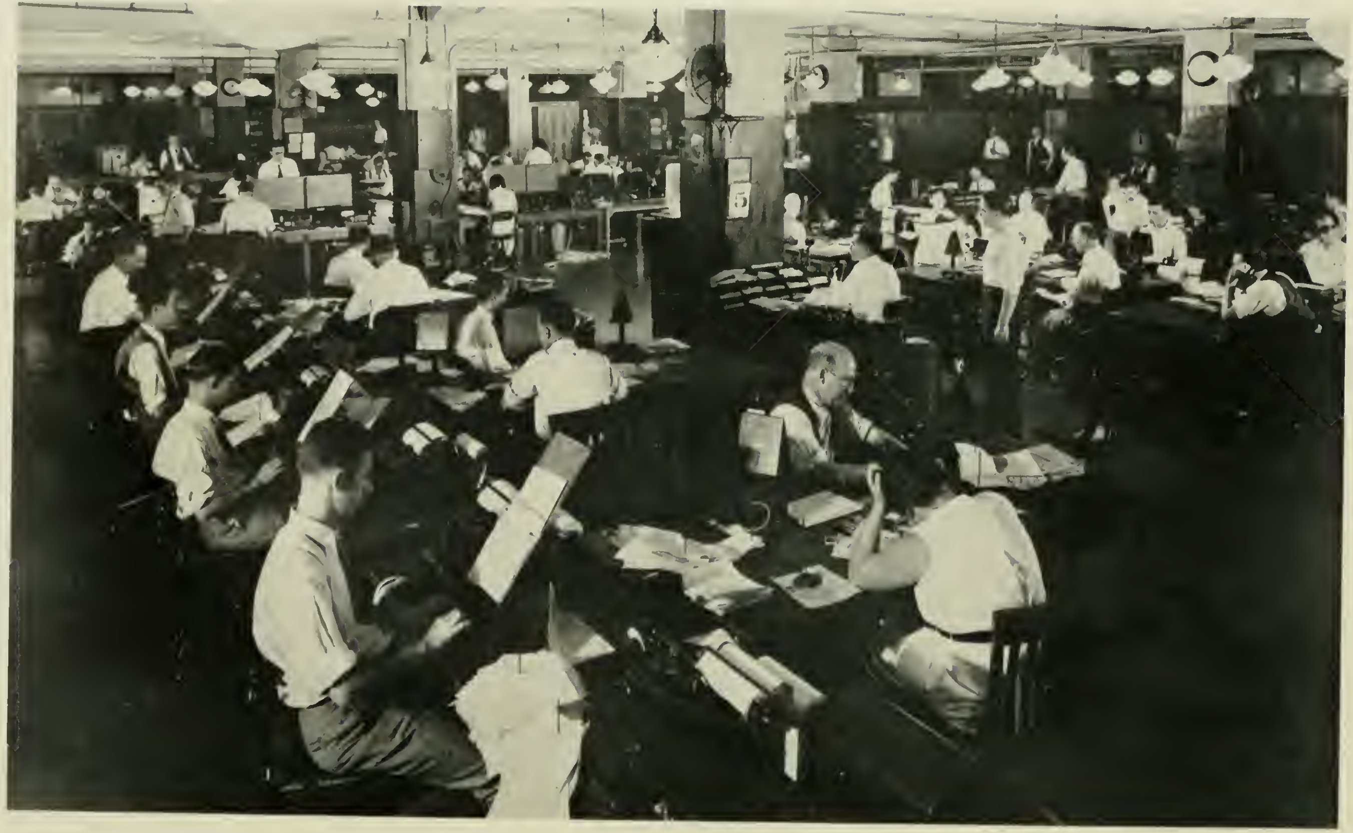
The listening public has been given countless opportunities to marvel at the wonders of telephony, and a broader conception of the part it plays in radio is being gained as time goes on. However, little thought has been given to the part that Bell System service plays in making the news of the day available to us in the daily press.

Our major press associations, The Associated Press, United Press Associations, International News Service and Universal Service, use all of our many forms of communication in the collection and dissemination of the news. Their wire systems consist of:

> *Teletypewriter service,* which forms the basis of their nation-wide trunk wire and state news distributing systems.
>
> *Telegraph service,* formerly the most extensively used class of service, which is now employed for the most part to supplement the teletypewriter service on trunk routes and for handling sporting results, such as baseball and racing.
>
> *Public News Telephone service,* furnished for fixed daily periods on a contract basis, which is used to deliver a limited report to the smallest newspapers.



News Room in the New York Office of the United Press. Showing the Elaborate Communication Equipment which Permits the Rapid Collection and Dissemination of News to and from All Parts of the World.



In the News Room of the New York Office of the Associated Press, Teletypewriter Operators are Sending Out Stories which are Being Received on Similar Machines by Member Newspapers as Fast as they are Typed in New York.

Teletypewriter Exchange service, our newest form of service, which is being used for administrative purposes and has superseded public news telephone service in some few cases.

Telephotograph service, which furnishes a rapid means of transmitting pictures associated with important news events in those instances where they are desired.

Toll service, principally used for collecting news at its source. Its scope extends to our transoceanic service for obtaining foreign news of major interest.

All of these services are utilized to cover spot news of the day, political developments during the sessions of Congress and the many State Legislatures, economic developments, sporting results and other types of news in which there is a wide public interest. The large newspapers require in addition to a news report, a complete tabulation of the daily fluctuations in stocks, bonds, cotton, grain and other basic commodities traded on the important exchanges of the country.

The general news report is transmitted to approximately 1300 cities and towns which have their own daily journals, and service networks extending from coast to coast and from our Northern boundary to the Southern are involved in its transmission. These networks also extend to the principal cities of Canada, to Havana, and to Mexico City, and require the use of approximately 400,000 miles of wire, 3600 teletypewriter machines and thousands of telephones.

As evidenced by the number of newspapers served and the different types of service used, the press associations have a varied news requirement to meet. To handle this with speed and accuracy, a well balanced division of circuit groups, both from the standpoint of traffic load and area, is a necessity. The trunk circuits, of which there are 150, and which operate on a double or triple wire basis, provide a medium through which the news is exchanged and at the same time serve the larger newspapers and news distributing centers of the press associations. They average from five to twelve points per circuit and are arranged so as to involve the least number of manual or mechanical relays for distributing the report.

News is exchanged between New York and San Francisco with but one repetition, and any important news happening reaches even the most remote point with not more than four relays. The distributing centers or Bureau Offices, as they are commonly referred to, are set up to edit the copy received to fit the needs of the medium sized newspapers which are served on a single wire basis. These single wire circuits, which usually operate within the bounds of one state, total 140 in number and range from ten to twenty points per circuit. Bureau Offices are also charged with the responsibility of transmitting to the smaller newspapers a suitable news report of from 700 to 1500 words per day by public news telephone service. These services require 190 circuits with an average of two receiving points per circuit.

With the trunk systems carrying more than 100,000 words per day and the single state circuits carrying approximately 25,000 words, the leased wire systems of the press are taxed at all times, but particularly so every four years when they are called upon to handle, in addition to the ordinary run of news, the collection and dissemination of the results of national elections. The total operating layouts on the night of November 8, 1932, were about three times greater than the normal nightly layouts, because of the need for additional facilities for exchanging the results throughout the country. Spare teletypewriter machines normally relied upon for protective purposes had to be utilized by the press associations to transmit or receive the facts and figures. However, the extra wire layouts in operation on election night were only what might be called the facilities required for putting the finishing touches to the job.

A means for gathering the election results from the various election precincts was needed during the day and well into the night. For this purpose toll service was as extensively used as any other form of communication, if not more so.

With this system set up and functioning, information as to the voting on presidential, gubernatorial and congressional candidates was relayed to the distributing centers, from which it was relayed into offices of hundreds of newspapers.

An undertaking of this magnitude required close co-operation between the operating forces of the press associations and the various branches of the Bell System personnel. The telephone operators were putting forth every effort to complete the toll calls as quickly as possible, the test rooms were monitoring teletypewriter and telegraph services, always alert to make any quick change in layout that wire conditions might warrant, and the maintenance forces were ready to respond to any emergency that might have arisen from the extended use of the teletypewriter equipment.

The service result and the manner in which it was received can best be explained by quoting the written and oral comments of the press associations. One said, "Our A. T. & T. circuits on election night worked so well and we received such excellent supervision over those wires that I can not help but write to you in commendation of the men in your organization responsible for the work." Another reported, "Our service on election night was fine. It was another case of where the A. T. & T. did its job without muffing the ball." From a third this was the comment: "Service furnished us on election night was without parallel."

HARRY JEAVONS

The Bell System Exhibit at the "Century of Progress" Exposition

THAT 1933 is the centennial of Chicago is the occasion for an international exposition—a "World's Fair"—which opens in that city on June 1. The past century, however, has a wider significance, and this the promoters symbolized in their choice of a name—*A Century of Progress* International Exposition. As they express it:

> In the hundred years of Chicago's existence, science has entered world industry and wrought amazing changes in everyday life. At the beginning of this era, man groped blindly for those laws which would enable him to mould the forces of Nature to his use and comfort. Today the results of that mastery of man over Nature are evident in new means of transportation, in new methods of communication, new processes of manufacturing, new weapons for fighting disease and new products that make our lives more comfortable, healthful and safe.
>
> A Century of Progress International Exposition will tell by easy stages and in simple form the story of scientific discoveries and inventions based on those discoveries, their application to industry and the resultant transformation that has made the world of today so different from the world of a century ago.

When the trustees of the Exposition, of which Rufus C. Dawes is president, decided that the Century of Progress should depict "the contributions of pure and applied science to industrial development during the last hundred years" as its main theme, they turned to the National Research Council for advice and assistance in formulating and developing that theme. The National Research Council, which is a coöperative organization of eighty national societies in the fields of science, engineering, and industrial technology, accepted the invitation and formed for that purpose a Science Advisory Committee with Dr. F. B. Jewett, Vice-President of the American Telephone and Telegraph Company, as its chairman. The presidents of a number of national societies were invited to appoint eminent men from their memberships to serve as individuals on that committee. Men were selected with a breadth of understanding sufficient to visualize a great national exposition along the line contemplated and of a standing which guaranteed the acceptance of their findings. To this group of professional members there was added a number of men, of wide interest in public affairs and in the broad application of science to national life, to serve on the committee as members-at-large.

This advisory committee, which through subcommittees expanded ultimately to include over four hundred members, represented the specific fields of science, engineering, and technology. Its studies, which were both extensive and detailed, resulted, after several months, in thirty-four complete reports covering the broader fields. These reports furnished the material for the basic plan and philosophy which the Science Advisory Committee submitted to the Exposition authorities. With the acceptance of its report, early in 1930, by the Exposition Trustees, the basic plan and philosophy of the Exposition became fully indicated. There remained for the Exposition itself the practical and financial problems (which were, of course, enhanced by the increasing economic depression) of the embodiment of this philosophy in buildings and exhibits.

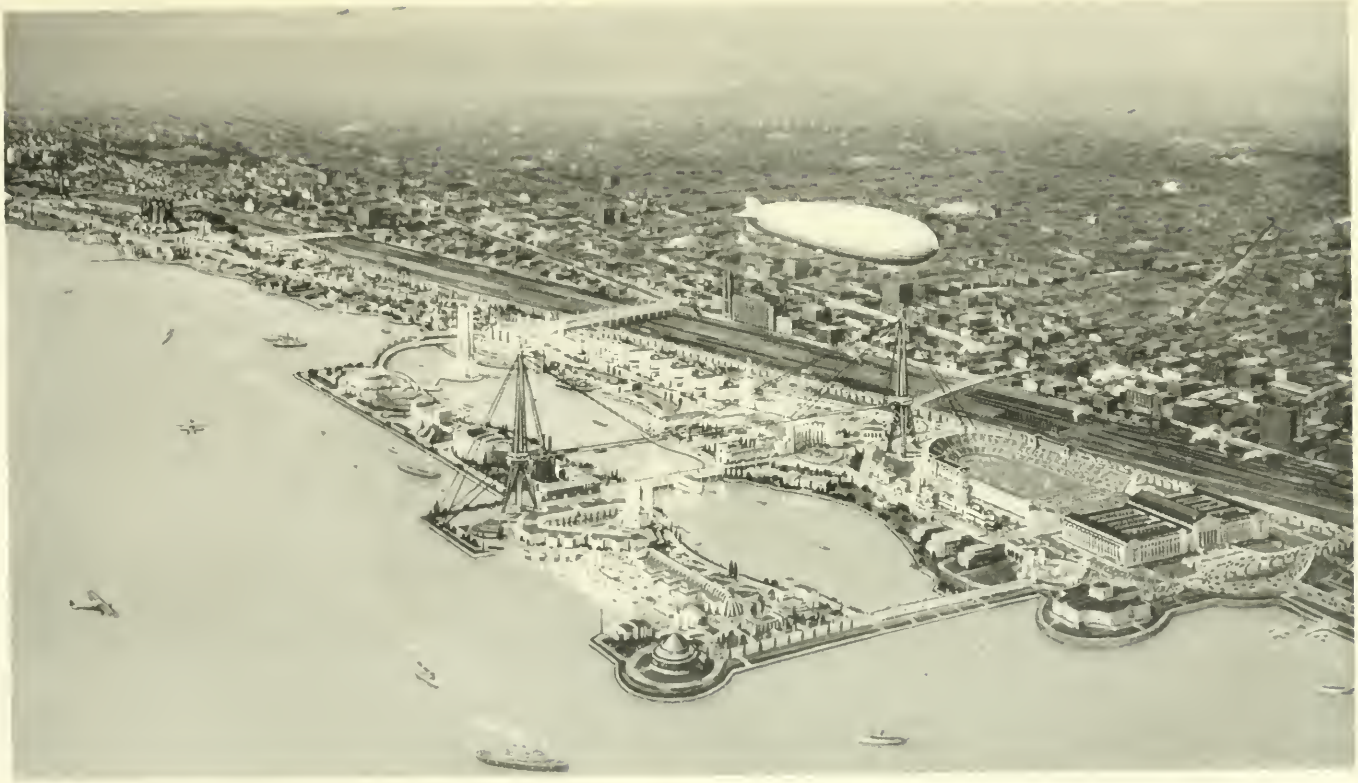
This exposition, incidentally, differs from its predecessors in being privately financed, not supported by subsidy from national, state, or city government, and not dependent upon government financial help. Its initial funds were raised by bond issues which were subscribed to by private individuals and local business enterprises. Those funds represent the confidence and community spirit of Chicago citizens. By that means were assured the construction of certain general buildings and exhibits and the operation of the Exposition. For the balance it was set up on a pay-as-you-enter basis where buildings were planned to meet the needs of various groups of exhibitors and were constructed as the leases were signed for the rental of their exhibit areas.

Foremost in the program of the Exposition, and of its advisors, was the construction of a vast Hall of Science which should house exhibits depicting the fundamental laws and phenomena of the various basic sciences. This building was one of the first erected and its scientific exhibits are, in general, to be arranged and paid for by the Exposition.

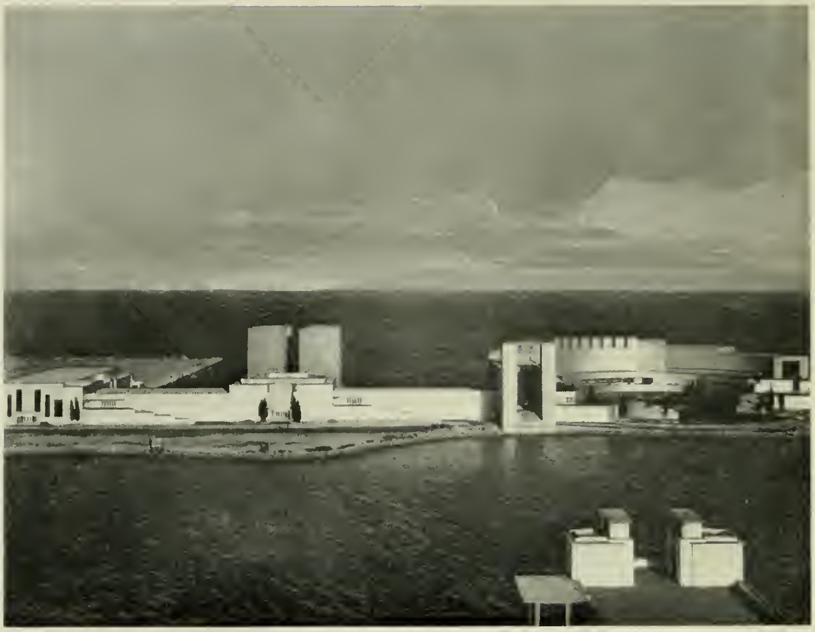
Starting from such a "temple of science" it was proposed that there should be grouped about it other buildings, representing industrial applications of the various sciences, with space leased to corresponding industries which would install appropriate exhibits. The first to be erected of these buildings representing applied science is an enormous framework, with a roof suspended on a catenary construction of cables, which is known as the Travel and Transport Building. The next to be erected was the electrical group. This was made possible by assurances of the major executives in that field that their organizations would take space and operate exhibits.

The central portion of this electrical group, which forms a long building of three interconnected sections, is the Communication Building. In this the Bell System, the Western Union Telegraph Company, and the International Telephone and Telegraph Company agreed to coöperate in maintaining an exhibit of the art of electrical communication in keeping with the philosophy of the exposition.

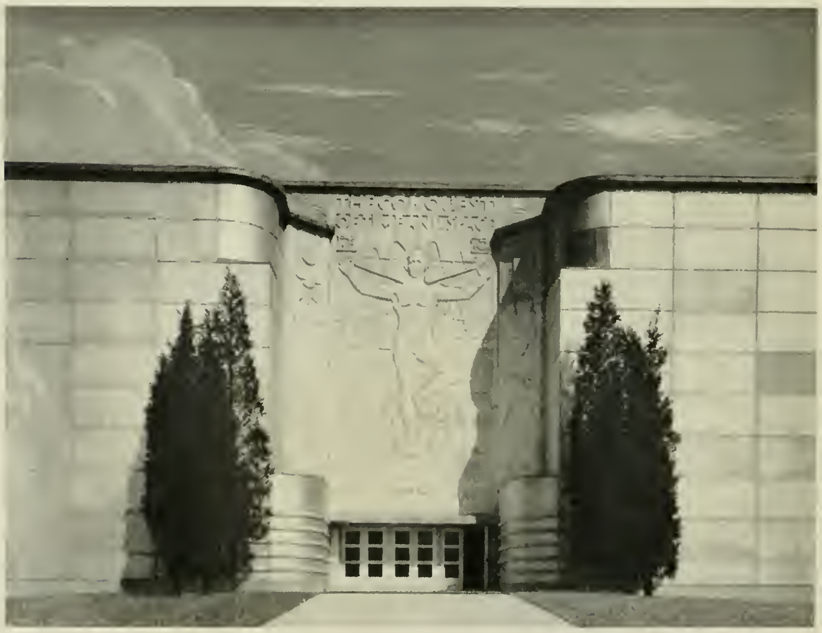
The Communication Building will house exhibits of *two-way* communication. The amusement applications of communication techniques, whether of radio broadcasting or of sound pictures, are to be located elsewhere. The technical unity of the communication arts, which arose from the inventions of Morse and Bell, their worldwide importance and service, the essential coöperation which communication implies and communication companies practice—all this, it is hoped, will be felt by the visitor to the Communication Building. Although there



Century of Progress Exposition. A Combination of Airplane View and Architect's Rendering. The Electrical Group Is Partially Hidden by the Steel Tower on the Left. The Bridge Connects the Northern End of the Electrical Group with the Hall of Science.



The Electrical Group as Viewed across the Lagoon from the Hall of Science. The Towers which Appear in the Central Background Enclose the Communication Court.



The Western Entrance to the Communication Building.

will be no exhibits in common and each of the three companies will occupy its own assigned space, there will be evident in the choice and arrangement of exhibits and the architecture of the building—particularly in its centrally located communication court—something of this underlying spirit of communication. In fact, the plans originally drawn for the electrical group were altered by its architect, Raymond Hood, with the approval of the Exposition authorities, and the exhibit areas proposed for communication industries regrouped to emphasize these ideas.

The Exposition, which is located on the lake front of Chicago, extends from about Twelfth to Thirty-first Streets. It occupies several hundred acres, reclaimed from Lake Michigan. It lies to the east of the Field Museum and Soldiers' Field, and extends south of that stadium on the east side of the Lief Ericsson Drive. A large part of the ground is essentially an island which extends south from the Adler Planetarium, enclosing with the mainland an attractive lagoon. The general location is shown by the accompanying picture, where the Soldiers' Field stadium, and the Adler Planetarium on the extreme left, are easily recognized points.

The Hall of Science is located on the mainland, and on the island directly across the lagoon from it is the electrical group. A bridge connects the two buildings, starting from the second floor of one and ending on the second floor of the other, but with ramps at either end to the ground level. One of the accompanying pictures shows the electrical group as viewed from the Hall of Science. In this picture the bridge, which is to the left, does not appear, for the view is taken from the portion of the Hall of Science which is directly opposite the Communication Building of the electrical group.

In the general picture of the Fair grounds the electrical group can be located by the connecting bridge, although in the picture it is partially hidden by a huge tower. These towers were not included in the original artistic visualization of the

Exposition grounds, and there is some divergence of opinion as to whether they add or detract from the general appearance. The towers, which are now in the course of erection, are the terminals for a ride across the lagoon at a level of 200 feet. They will be about 600 feet high and at their tops have observation platforms and restaurant facilities.

The Communication Building has eight different entrances, and only a good guess can be made at present as to which will prove the most popular. The building, plans of which are shown in an accompanying diagram, consists really of two parts: one portion forms a continuous part of the electrical group, and the other, consisting of four separate high towers, forms a court or formal garden on the lake side of the main portion of the building.

These four towers, of rough concrete, run up about 110 feet. They will probably be colored in green and in effect form huge " trees " enclosing a quiet space which will be the " Communication Court." The towers are about twenty feet apart and the court may be entered from the north, east, or south. In the center of the court is a shallow pool for which a tile bottom is being constructed bearing a design symbolic of the speed and world-wide range of electrical communication, and on the border the names of the three industries. The towers will be colored and specially illuminated at night, and the quiet center which they form on the lake front should prove very attractive. In the base of each tower is a pavilion of about 700 square feet area.

The northwest and southwest pavilions connect directly with the adjacent exhibit areas in the main building. Between these two pavilions, as shown in the accompanying floor plans, there is a wide entrance on the first floor of the Communication Building. Broad winding stairs also lead around the outside of the two western towers to the second floor of the main building from which there is another entrance to the building.

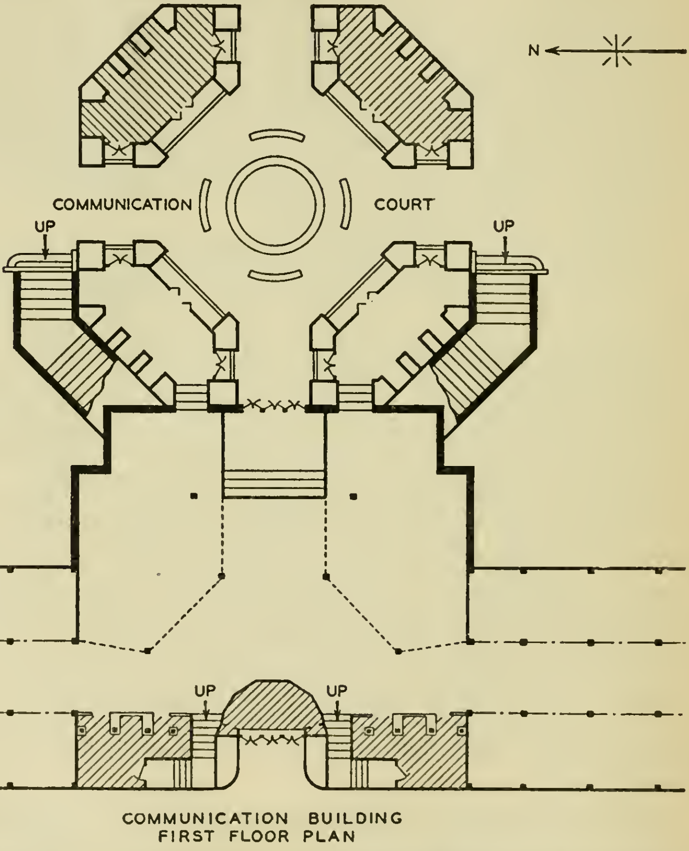
In the division of space between the American Telephone and Telegraph Company, the Western Union Telegraph Company, and the International Telephone and Telegraph Company, the two eastern pavilions were taken by the Bell System, the northwest by the Western Union and the southwest by the International. The spaces on the first floor of the main building immediately adjoining the western pavilions are occupied by the last named companies. Across the hall on the west side of the building and on either side of the doorway are spaces assigned to the Bell System. An aisle with exhibit booths on each side connects the Communication Building to the other sections of the electrical group.

On the second floor, the aisle from the other sections swings around a balcony rail, leaving a well or large open space from the ground floor to the roof. In addition to the entrance reached by stairways around the pavilions, there is another second floor entrance. This is provided by an exterior flight of stairs which ends in a wide doorway into the corridor at a point just south of the Communication Building.

The two large triangular areas and the two smaller rectangular ones on the second floor are Bell System spaces. In addition, a semicircular mezzanine balcony is being erected over the west doorway and projecting into the well. The demonstration which will take place in this area, which is also a Bell System area, will be observed from the edge of the balcony, along which there are being provided a few seats and a protecting rail.

The Bell System exhibit occupies, as is evident from the accompanying sketches, nine separate areas. Although these are apparently widely scattered, it will be recognized that they are also strategically placed so that one or more of them adjoin every entrance to the Communication Building. Furthermore, the entire second floor is devoted solely to Bell System exhibits, and through appropriate decorative treatment and a patterned floor covering it will have a distinct unity of its own.

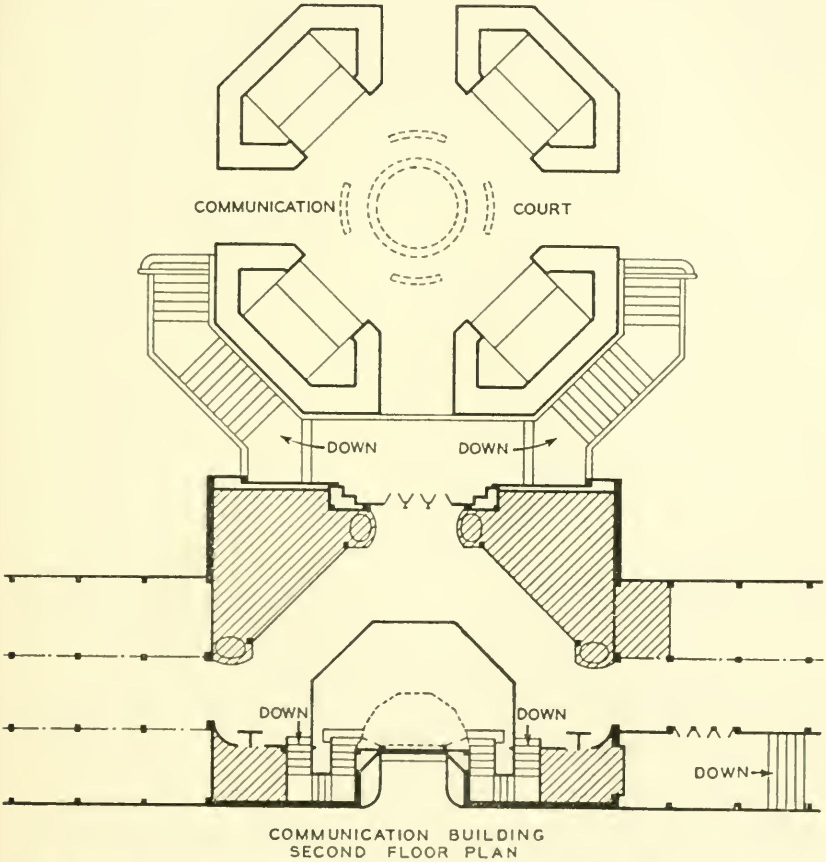
Plans for the occupancy of the other space in the Electrical Building have undergone alteration since their original projection. The south end of the building—a semicircle around an electrical court—will be occupied, as was originally planned, by the light and power industry and its manufacturing companies. Recent alteration of plans has affected, however, the north end of the building which was originally proposed for radio and, it was hoped, for television. For various reasons these plans have been changed and the north end will be



Plan Showing First Floor and Pavilions of the Communication Building. Shaded Areas are Exhibit Areas of the Bell System.

devoted to social science, with the intervening exhibit areas allotted to radio companies.

Arrangements for the Bell System exhibit, which have been carried on under the general direction of Vice-Presidents A. W. Page and F. B. Jewett, of the American Telephone and Telegraph Company, have been rather definitely in consonance with the fundamental plan of the Exposition to show the industrial applications of pure science in two-way communication. In planning the exhibit, a definite philosophy was first



Second Floor Plan, Showing Outline of Concrete Towers, which Rise a Hundred Feet above the Pavilions, and Stairways to a Balcony Entrance to the Communication Building.

required. Attacking that problem by asking what message the Bell System should convey to the public through its exhibit, it was felt that the exhibit as a whole should emphasize: (*a*) the institutional character and policy of the Bell System; (*b*) the nature and extent of the plant and equipment which lies behind the terminal apparatus with which subscribers are familiar and the operations involved in rendering the services which the System offers; and (*c*) a fuller knowledge of these services and of the convenience and economy accompanying their use.

With this point of view, the two pavilions have been made institutional exhibits and headquarters for the exhibit. Incidentally, to a considerable extent the two other companies in the Communication Building are giving similar treatment to their pavilions so that the "Communication Court" promises a quiet, dignified presentation of the institutional character of the organizations most concerned in two-way communication. The two areas on the first floor are commercial in character and devoted, one to the exemplification of the convenience of the telephone in home and office, and the other to the economies which Bell System services offer to the business man in intercity communication, with particular reference to teletypewriter service, keytown selling, and the like.

In the areas devoted to the convenience and economy of Bell System services there will be representatives who can discuss with interested visitors any of these services. There will also be exhibits of substation equipment and of teletypewriters and some related demonstrations of a scientific character. For example, there will be provided in one exhibit area an oscillograph and associated with it a loud speaker. This oscillograph will show the wave form of words which come from the loud speaker. The apparatus will give an idea of the complexity and range of sounds which must be accurately transmitted and reproduced in order to give high quality telephone service. In the other exhibit area there is proposed a small demonstration equipment to show the operation of a step-by-step system of switching. This demonstration will operate in response to dialing by a visitor.

The second floor areas are devoted to illustrating the equipment and methods of operation which lie behind the scenes in Bell System services. One large triangular space will contain an exhibit of panel switching in which there will appear the various types of frames necessary in central offices. Demonstration calls can be made through this equipment. One demonstration call will be set up and carried out automatically once every minute with attention directed to the operations involved by flashing signs and by lights on the moving parts of the mechanism. Other parts of the mechanism will be in operation as if transmitting calls, so as to give some idea of the type, although not of the extent, of equipment and operations involved in dial central offices. Three dial telephones will also be provided nearby at the desk of an attendant from which any visitor may dial any one of three other telephones on the opposite side of the desk and while doing so trace through appropriately colored lights the operations of the mechanism and the progress of his particular call through the panel frames.

This dial telephone exhibit illustrates one of the principles adopted in planning all the other exhibits. First, for the visitor who would hurry by, it provides some impression of the magnitude and complexity of the operations involved in interconnecting telephone subscribers. For the man who is attracted and willing to spend a little more time it provides an opportunity to take part himself in the demonstration by dialing a call of his own selection and observing its progress. And third, it provides for those with further interest a chance to examine the equipment in detail and on a reading desk extending beneath the equipment to find sufficiently complete and technical explanations. In general an attempt has been made to provide in each instance an exhibit and material suited to all degrees of comprehension and interest from the casual to the expert.

The other triangular area will be devoted to a demonstration of the speed and quality of intercity telephone service, with demonstrations of telephone calls from Chicago to one or two important cities in each state of the Union.

The two rectangular areas on the same floor will be devoted to engineering demonstrations of proven and popular interest. One consists of inverted speech and privacy of radio telephone conversations, and the other of carrier-current communication and the multiple channel use of lines. The mezzanine balcony will contain demonstrations of scientific character the details of which are now being worked out.

In addition to the exhibit areas just described, four small elliptical areas are obtained by partitioning off the exterior corners of the two triangular areas, as may be seen from the second floor plan. In each of these there will be demonstrated some typical operation which is involved in rendering communication service. To visualize one of these demonstrations one imagines a central office where a black cloth is spread so as to hide all the switchboard and all its operators, except just one position and the operator in front of it. That is what the visitor to the Exposition will see in each of these four niches. A mild spotlight concealed above will illuminate the position and its operator, and the back and sides of the niche will be finished in dull black. Through an arrangement of cams and relays a dummy or fictitious load will be produced so that the operator will carry on the usual type of operations. The load, although characteristic in types of operation, will be lighter than usual and she will be expected to answer questions on the part of visitors. So that she may pause to answer, a switch will be provided by which she can momentarily interrupt the signals of the dummy load. It is planned also that her voice shall be assisted by a lapel microphone and a small concealed loud speaker.

The four positions to be thus demonstrated are those of a manual operator in the central office of a small city; a dial service operator who, in a large dial exchange, performs various services for subscribers; a call announcer operator of a metropolitan area; and a teletypewriter exchange operator. In the case of the call announcer position it will be possible for the visitor himself to dial any four digit number which he desires and hear the words as does an operator at such a position. Incidentally, adjoining this operator's position in this case there will also be call indicator equipment which will be available for the visitor to demonstrate for himself by dialing.

The teletypewriter exchange operator, in addition to carrying a fictitious load, will actually perform upon signal the switching operations required by either of two teletypewriters which are exhibited in the commercial space on the floor below. There will thus be possible a complete demonstration of both terminals of a teletypewriter system and of the "T.W.X. position."

In a similar way the operator at the manual position will give service to a number of telephones located for demonstration purposes in the first floor area which is devoted to the convenience of telephones in home and office.

Such in general is the character of the Bell System exhibit which the American Telephone and Telegraph Company is planning at the Century of Progress on behalf of its associated companies.

The erection of the building was completed some time ago and the installation of switchboard equipment is now being carried out by the Western Electric Company.

Such a wide variety of services, of equipment, of engineering techniques and operating practices is involved in the work of the Bell System that no limited exhibit can adequately portray its work. Selection, therefore, was necessary and only a small number of typical operations was possible. Those chosen, in general, are those which have proven to be of greatest interest to visitors to the telephone plant and to the Laboratories. It is probable, therefore, that they will attract favorable attention and will interest the large section of the public which has been unable to visit central offices.

A general question, however, arises in the minds of many people as to the probable extent of attendance at this exposition. To some it appears at first glance that world's fairs are out of date; that magazines and Sunday supplements and newsreels and the mobility which the public has acquired through the automobile and other improved transportation services make such expositions unnecessary as a means for the dissemination of information and education. On the other hand, this very mobility which the automobile has made possible means a greater ease in taking advantage of the exposition and it is confidently expected by the Exposition authorities that, whatever may be the attendance from great distances, there will be an enormous attendance from within one day's drive of Chicago. The authorities, in coöperation with other city agencies, are planning highway routing schemes, information centers, authorized tourist camps, and a number of other means for facilitating visits by automobile. The confidence which they have appears to be shared by others; and there seems to be considerable ground for belief that the exposition, which will undoubtedly open on time, will prove a success.

John Mills

Editor's Note: Mr. Mills is of the staff of the Bell Telephone Laboratories and from the inception of the general idea of Bell System participation in the Chicago Exposition has been in charge of all arrangements involved in executing the architectural and technical plans.

The International Telegraph and Radio Conferences of Madrid

BEGINNING on September 3 and continuing until December 10, 1932, there occurred at Madrid, Spain, an important world conference on international electrical communications. It was unique in being the first general international conference to review in its entirety the whole field of international electric communications, including telegraph, telephone and radio. It was, in reality, a dual conference representing two meetings held simultaneously, and in some respects jointly, under each of the two existing treaties, one the International Telegraph Convention of St. Petersburg of 1875, with its more recently revised Regulations, and the other, the International Radiotelegraph Convention of Washington, 1927.

There had grown up a desire on the part of many nations of the world to combine these existing conventions and their associated regulations into a co-ordinated whole, and the object of holding the two Madrid meetings simultaneously was to undertake the working out of a combined convention. But principally there was the task of bringing these older conventions with their regulations up to date and, in so doing, settling several questions which had become of rather pressing importance in recent years. Outstanding among these problems in the field of telegraphy was the question of the length of the code word to be used in code language telegrams, and in the field of radio, the question of satisying the demands of the various countries of Europe for additional waves for broadcasting.

The conferences met under the chairmanship of the Spanish Government and consisted of delegates from about 75 countries, together with representatives from about 50 communication companies and from nearly 30 other invited organizations having some interest in the questions under consideration. In all, about 600 persons were in attendance. The secretarial work was carried on by the International Bureau of the Telegraph Union, assisted by the Spanish Government. The discussions were carried on in both French and English, interpreters having been furnished by the United States Government, although hereafter they are to be furnished by the International Bureau. The documents of the conference were issued in French, the translations into English by the American delegation were made available to the delegates of other countries who wished to have them. The magnitude of the task of the conference may be appreciated from its scope and the fact that it had for its consideration approximately three thousand proposals.

Convention

The Convention, as adopted, combines the principal provisions of both of the previously existing Conventions. It is applicable to telegraph and telephone services whether conducted by wire or radio, and also to broadcasting and other special forms of radio communication. Its first article provides that the countries which are parties to the Convention form the "International Telecommunication Union." Succeeding articles provide for the organization of the Union and the conduct of conferences for the revision of the Convention and Regulations. Another group of articles contains general provisions applicable to telegraph and telephone services, such as those relating to secrecy, non-discrimination, suspension of service, etc. A third group of articles relates entirely to radio communication and is taken substantially from the Washington Convention. The Convention is to go into effect on January 1, 1934.

One of the important provisions of the Convention makes the Convention binding on a given government only as regards those services which are covered by the Regulations which have been adopted by that government. There are three separate sets of Regulations supplementing the Convention, those relating to telegraph, telephone and radio communication. The Convention makes obligatory the signing of only one of these sets of Regulations. The Radio Regulations are divided into "General" and "Supplementary Regulations," the signing of the latter not being obligatory on parties to the former. The delegates of the United States of America signed only the Convention and the General Radio Communication Regulations. The effect of these provisions, therefore, is that while the Convention is a combined telegraph, telephone and radio convention as to form, it is applicable to a given service only to the extent that each government undertakes to be bound by the regulations governing that service. In the case of the United States, therefore, the practical result is to make substantially no change in the situation which existed before the combining of the Conventions. Thus, the action of the conference recognizes the position which the United States has always maintained, namely, that the government undertake obligations only on matters of true governmental concern, and that the procedure for handling international communication service be determined, in accordance with American law and practice, by the operating agencies which furnish the service. The provision of the Convention is such, however, that the participation of the American operating agencies in conferences for the revision of these regulations is only in an advisory status and without vote.

One of the questions which occupied a large amount of time of the conference was the determination of the basis on which the voting would be conducted. It was impossible to reach agreement on a permanent provision for inclusion in the Convention and the United States Government was asked to continue its efforts to secure a solution through diplomatic negotiations. The conference did, however, a few weeks before its close, adopt a temporary rule governing voting at the Madrid

Conference. The difficulties which were met in connection with this question served to emphasize how complex is this problem of representation in a specialized field where technical and economic development, as well as political sovereignty, come into play.

Radio Communication Regulations

The Radio Communication Regulations, annexed to the Convention, consist of a revision of the Regulations adopted at Washington in 1927. No major changes were made in the table giving the allocation of frequencies to the various services. Fuller recognition is given, however, both in the allocation table and in the provisions of the Regulations themselves, to the freedom which each region should have to organize its own radio services, but with the requirement that interference with other regions will not result. To satisfy the pressure which exists in Europe for the expansion of the wave lengths available for broadcasting, the range from 160 to 265 kilocycles was made available for European broadcasting, and an agreement was reached to subdivide this range among the European countries at a regional conference to be held in June, 1933. While the countries of North America reached no agreement at Madrid on any expansion of the broadcasting range, presumably there will be opportunity to consider this problem further at a North American regional radio conference which is to be held at Mexico City in the Spring of 1933.

The Regulations relating to the use of frequencies in the mobile radio service were revised. These rules relate to such matters as the procedure for calling and answering, the handling of distress and emergency messages in the aviation and marine services, certain provisions relating to ship-to-shore telephony, etc.

As at the Washington Conference, the radio regulations which relate primarily to the handling of radiotelegraph message traffic in the marine service were grouped in a supplementary section, subject to separate signature, in order that they might not become obligatory on countries like the United States and Canada in which the government does not operate the public international communication services.

TELEGRAPH REGULATIONS

The Telegraph Regulations, as distinguished from the Convention to which they are annexed, have been revised from time to time and were last revised at Brussels in 1928. While many points of detail were modified at the Madrid Conference, the most significant change is that relating to the handling of telegrams in code language. Hereafter such telegrams are to be charged for as consisting of words or groups of five characters each (formerly ten-letter groups were permitted as well). The charge for the transmission of a five-letter group is to be 60 per cent of that for a plain-language word in the extra-European service and 70 per cent in the European service. Formerly these factors were 66 2/3 per cent and 75 per cent, respectively.

The chapter of the Telegraph Regulations relating to the transmission of radiotelegrams in the marine service has been omitted, this subject being left entirely to the Radio Communication Regulations (principally the Supplementary Regulations).

TELEPHONE REGULATIONS

The Telephone Regulations, annexed to the Convention, consist of a revision of the Regulations which formerly comprised a telephone chapter of the Telegraph Regulations. The first article of the Telephone Regulations provides that they are applicable only to international telephone service over circuits which are entirely within the European regime, the conditions and practices in Europe differing materially from those obtaining in America. The practices to be followed on intercontinental services and generally in regions outside of the

European regime are left to determination directly by the operating agencies concerned.

International Consulting Committees

The three International Consulting Committees, on telephony, telegraphy and radio, are continued in substantially their previous status. The provisions relating to their constitution and functions are contained in the respective Regulations, the Convention article merely providing that such committees may be formed. The provisions relating to the three committees have been made slightly more uniform than previously; membership in all may be had both by governments and by private operating agencies; voting takes place in accordance with the rules applied to the conduct of the preceding administrative conference, except that where a country is not represented by a government telegraph, telephone or radio administration, as the case may be, the vote for that country may be cast by the corresponding member companies as a whole. In general, the Telephone Committee, which will hereafter be designated as C. C. I. F., and the Telegraph Committee (C. C. I. T.) are to meet every two years, while the Radio Committee (C. C. I. R.) is to meet once every five years, i.e., once between each two radio administrative conferences. As a consequence of the rapid development of the radio art, however, it is possible that an additional meeting of the C. C. I. R. will be held in connection with the next administrative radio conference. Provision is made for the holding of special meetings on the request of a sufficient number of countries.

Reservations—European Protocol

A number of reservations were appended to the Telegraph and Radio Regulations. In view of the present instability of the currencies of various countries, with respect to gold, about 30 countries reserved their right not to apply the provisions of the Telegraph Regulations whereby rates equivalent to those originally quoted in gold francs would have to be collected from the users of the international telegraph service.

Several countries took exception to certain detailed provisions of the Radio Regulations, the most notable being the reservations which a number of countries made with regard to the frequency bands allocated to broadcasting. The delegation of the Union of Soviet Socialist Republics declared that it intended to continue to use for broadcasting, aviation and direction finding, certain of the long wave bands between 150 and 550 kilocycles, which it had been able to use for those purposes in view of its not being a party to the Washington Convention, and which bands are allocated, so far as the rest of the world is concerned, largely to maritime mobile service. Several countries gave notice of their readiness to protect their services against interference from any broadcasting stations of the Soviet Republics which might operate outside of the generally accepted bands.

A group of about ten European countries which are primarily interested in improving the wave length status of their broadcasting stations gave notice that unless the forthcoming European radio conference makes adequate provision for their broadcasting stations, these countries will not ratify the Radio Communication Regulations signed at Madrid. After the conference had spent several weeks in an attempt to reach complete agreement on the allocation of frequency bands to European broadcasting, aviation and marine services in the long wave range, it was finally agreed to make few changes in the present allocation but to rely upon a solution of this problem by the European Conference.

The detailed basis of action of the European Conference and authority to depart, in certain respects, from the Madrid allocation, was formulated in a European protocol signed by the European delegates at the same time as the Convention. The protocol places a tentative limitation of 150 kilowatts on the power of European broadcasting stations and proposes certain limitations on the strength of signals to be produced in order to minimize interference in adjacent countries. This protocol also provides that a tentative allocation of specific frequencies to broadcasting stations in Europe shall be formulated by the International Broadcasting Union (of Europe) and that this allocation shall serve as the basis for discussion at the European Conference to be held in Switzerland in June, 1933.

Subsequent Conferences

The Madrid Conference accepted the invitation of the Government of Egypt to hold the next general conference at Cairo in 1937. That conference will, in reality, consist of three separate "administrative" conferences, meeting simultaneously, to revise the Telegraph, Telephone and Radio Communication Regulations, respectively.

Representation

The United States Government was represented at this conference by the following official delegates: Judge Eugene O. Sykes, Dr. C. B. Jolliffe, Dr. Irvin Stewart and Dr. Walter Lichtenstein. In addition, technical advisers were present from the Departments of Navy, War, Commerce and Treasury and the Federal Radio Commission. The American Telephone and Telegraph Company was represented during all or part of the conference, by Messrs. E. S. Wilson, H. E. Shreeve, Lloyd Espenschied, J. F. Bratney, L. E. Whittemore and Knud Fick. Representatives were also present from the other principal communication companies of the United States.

L. Espenschied
L. E. Whittemore

Notes on Recent Occurrences

VICE PRESIDENT GHERARDI RECEIVES EDISON MEDAL

THE Edison Medal for 1932 has been awarded by the American Institute of Electrical Engineers to Bancroft Gherardi "for his contributions to the art of telephone engineering and the development of electrical communication."

The Edison Medal was founded by associates and friends of Thomas A. Edison, and is awarded annually for "meritorious achievement in electrical science, electrical engineering, or the electrical arts" by a committee consisting of twenty-four members of the American Institute of Electrical Engineers.

The following eminent engineers and scientists have been recipients of the medal: Elihu Thomson, Frank J. Sprague, George Westinghouse, William Stanley, Charles F. Brush, Alexander Graham Bell, Nikola Tesla, John J. Carty, Benjamin G. Lamme, W. L. R. Emmet, Michael I. Pupin, Cummings C. Chesney, Robert A. Millikan, John W. Lieb, John White Howell, Harris J. Ryan, William D. Coolidge, Frank B. Jewett, Charles F. Scott, Frank Conrad, and Edwin W. Rice, Jr.

The Institute's announcement of the award of the Edison Medal to Mr. Gherardi said in part:

> Mr. Gherardi's entire professional and business career has been devoted to the art of communication. Coming into this field when the telephone art was very young (300,000 telephones in 1895) he has played a most important part in the development and perfection of operating practises and in the development of methods, equipment, and apparatus, which have brought telephone communication to the high state of perfection in which we find it today.
>
> Mr. Gherardi has directed the development and introduction of many new and improved arrangements which are in use today on a large scale, and which have added greatly to the speed and accuracy of local and long distance telephone service.

His broad vision as to the place of communication, not only in the affairs of the people of the United States but also in world affairs, and his initiative and skill in the development of engineering and operating organizations and in the development of the art generally, have contributed enormously to the growth and success of present-day communication.

FLORIDA RADIO STATIONS EXTEND SERVICE SOUTHWARD

OPENING of overseas telephone service through the newly constructed short wave radio telephone transmitting and receiving stations of the American Telephone and Telegraph Company at Miami, Florida, took place during last December with the official inauguration of voice communication between the United States and the Bahama Islands, Colombia, and Venezuela. The transmitting station is at Opa Locka, about ten miles outside of Miami, and the receiving station is at Hialeah, about five miles from that city. The stations are connected with the rest of the Bell System by land lines, and service to the three overseas points is available to all Bell and Bell-connecting telephones in the United States, Canada, Cuba, and Mexico.

Venezuela and Colombia become the sixth and seventh South American republics with which North America now has direct telephonic connection, since service has been in operation to Argentina, Brazil, Chile, Peru, and Uruguay. The Bahamas are the first of the islands of the Caribbean to which radio telephone service is extended, the circuits between this country and Cuba being in deep sea cables.

Service to the Bahamas was opened on December 16, and for the present is limited to Nassau. The charge for a three-minute conversation between New York and the island city is $15.00.

On December 19 service was opened to Venezuela, connecting there with the lines of the Compania Anonima Nacional

Telefonos de Venezuela which cover most of Venezuela's northern seaboard. The cost of a three-minute conversation is $24.00.

Service with Colombia was opened on December 22, the connection at the far end being with Compania Telefonica Central at Bogota. The cost for a three-minute conversation is $24.00.

Service to all three points was inaugurated by an interchange of greetings among government and telephone officials.

SERVICE EXTENDED TO LISBON

ON December 5, overseas telephone service was extended to Lisbon, Portugal, over the regular radio telephone circuits between New York and London and thence by wire via Madrid. Service is available to all Bell and Bell-connecting telephones on this continent and in Cuba, and the charge for a three-minute conversation is $37.50.

CABLE EXTENDED TO DALLAS

WITH the completion of the final links in the line between Kansas City and Dallas, Long Lines toll cable now extends westward to the latter city. The length of the cable between New York and Dallas is about 1950 miles. Service between the two cities over all-cable circuits is scheduled to begin this month.

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A Medium of Suggestion
and a Record of Progress

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Long Distance and a Thrill-Packed Month

NEWSPAPER men, and telephone men, too, will not soon forget the series of dramatic events which jammed the calendar from February 15 to March 12, 1933. Beginning with the former date, which marked an assassin's attempt on the life of the President-elect, Bell System services figured almost constantly in news dispatches for four weeks. In quick succession came such major happenings as the inaugural, a national bank holiday, Mayor Cermak's death, an earthquake and President Roosevelt's radio address on banking at the end of seven days in office—seven days which made history at a breathless tempo.

* * *

Scanning press reports as they came along through that history-making fortnight one gained the conviction that no dreamer could have conceived a more swiftly moving, more varied series of tests by which to evaluate the telephone and its associated functions as servants of humankind.

Bullets spouted from an assassin's revolver at Miami and the smoke had scarcely cleared away before reporters were rushing for telephones and calling "long distance" to speed verbal accounts of the scene to news distributing centers at Washington, New York and elsewhere.

Within a few minutes the communications office at the White House burst into jangling activity as newsgatherers all at once poured in reports by telephone. Meanwhile, press wires were flashing the story and its sidelights to the farthest corners of the nation. In this instance, as a paraphrase, "shots heard round the world" comes nearer being literally true than was the case in the famous poem.

A little later Mrs. Roosevelt telephoned her husband from their New York City home and received his calm reassurance. Still following press reports, we are told that a Philadelphia friend of the Roosevelt family heard the news during a long distance conversation to Pittsburgh, and immediately hung up to put through a call to Mrs. Roosevelt for first-hand information.

Other uses of long distance pass in quick review: Dr. Joel T. Boone, physician of President Hoover, called from Washington and found the President-elect at the hospital with Mayor Cermak and the four other victims; President Hoover constantly was kept advised of their condition; Secret Service operatives questioned the assassin and telephoned the results to their Chief at Washington. Two days after the shooting, as Mr. Roosevelt's special train proceeded northward to Washington, a telephone was put aboard at every stop while the President-elect personally obtained reports from the Miami hospital.

Chicago doctors held a telephone consultation with Miami physicians concerning the stricken Mayor. . . . And after nineteen days his secretary turned from a telephone in Chicago to break the news to assembled friends: "Tony is dead."

* * *

This depressing news broke over the country at one of the most critical times in our national history, resulting from a series of bank holidays declared by various States in rapid succession. This phase of the now-familiar depression had begun in Michigan on February 14.

Again we find the telephone industry prominently in the picture. Behind the scenes traffic charts indicated that something unusual was happening. On the day that the Michigan banks closed, the number of long distance messages doubled in the Detroit office. The same was true at Cleveland on February 27. For the period from February 14 to March 13 (when the national banking holiday was partially lifted) long distance traffic figures, averaged for fourteen large cities, crazily bounced up and down as conditions changed from day to day. On some days traffic was below normal while at other times the daily figures showed increases up to 15 per cent. Over the first week-end in March, traffic fluctuated widely from its usual limits, varying from 15 per cent above normal to 15 per cent below.

During this time, approximately 1,200 additional circuits were put into service by the Long Lines Department of the American Telephone and Telegraph Company. Overseas traffic figures also were affected in a startling way. The heaviest day for transatlantic telephoning was Saturday, March 4, which showed 91 calls. With South America, Bermuda and Ship-to-Shore services added to those overseas, the maximum day's business showed 116 calls. Total radio-telephone business during the bank holiday period reflected a world-wide interest in the financial troubles of the United States.

The details of conversation and telegraph messages exchanged by financiers and others during this momentous time must be left to conjecture. Outward manifestations of action, however, are plentiful as we turn again to the news dispatches. In the dark hours of the night before inauguration, when State closures had become an avalanche, both the President and the President-elect, with their advisors, turned to long distance time and again, marshaling reconstructive forces over a country-wide front.

Next morning found a mounting feeling of apprehension among the thousands of visitors in Washington. Most of them discovered that funds in their home States were tied up and that checks were practically non-negotiable in the capital. Thus, the man in the street, as had those in high places the night before, turned to long distance. Across the miles in every direction went spoken appeals for cash.

Many State Governors, in Washington for the inauguration and remaining for a conference with the new President two days later, frequently talked with their lieutenants at home.

To distant State officials Treasury experts gave verbal rulings, instructions or information concerning scrip.

* * *

Since the banking troubles overlapped inauguration activities, Bell System services and personnel obviously could not function in a single-minded fashion. Both of these major operations had to be carried on at the same time. But the fact remains that the inaugural assignment was a man-sized one by itself. The system of circuits set up for the National Broadcasting Company and Columbia Broadcasting System chains was more elaborate than for any previous inauguration. While nothing fundamentally new was done, there was a closer approach to perfection in circuits and other communication facilities than any other inaugural enjoyed.

Counting the facilities provided in America and in Europe it is estimated that 100,000,000 radio listeners were able to tune in on the proceedings. The program was carried over 35,000 circuit miles of wire to 175 stations in this country, and was re-broadcast in England and Germany.

More long distance calls were handled than on any previous day in Washington's history. The volume of traffic had been mounting for three days previously, as may be gathered from the fact that the long distance traffic of March 1 was greater than on Christmas Eve.

The normal group of 191 Long Lines circuits out of Washington was increased to 303 during the inauguration period. Included in the extra 112 circuits were 14 to Philadelphia, 26 to New York, 11 to Pittsburgh, 9 to Richmond and 7 to Chicago.

* * *

For all its swiftly-paced drama and tense excitement the period just reviewed was hardly more than a prologue. Immediately after the inauguration, President Roosevelt became the central figure in a political drama which redoubled the courage and lifted the hearts of a people: night-long conferences by State and Federal officials; Presidential proclamations and messages with a wartime crackle; Congressional action at record speed. Through it all, communication services were instantly recording each move in detail for a nation which seemed suddenly drawn together in a community of spirit.

This was the moment selected by Nature to inject the Southern California earthquake—a crashing entrance upon a stage already crowded.

Again the telephone took the cue from hundreds of frantic relatives, friends and others interested in the fate of the stricken area. The disaster occurred late in the afternoon on Friday March 10. Between midnight and 5 A.M., 128 calls were reported from New York to California. All these calls were cleared by 7 A.M. Meanwhile, 91 others had been filed. The delays experienced were not due to lack of facilities so much as to the difficulty of locating those who were being called.

From midnight after the quake began, to 6 P.M. of the following day (Sunday) 1,042 long distance calls went through New York switchboards to Long Beach and Los Angeles. More than 900 of the calls originated in New York, while the rest came from European cities, with two calls from newspapers in South Africa and Australia respectively.

The normal outward toll board traffic from Los Angeles amounts to about 11,500 calls. Contrasted to this there were 31,000 on Saturday following the earthquake. Segregating Long Lines circuits from the local company toll lines we have a normal average of 280 calls per day out of Los Angeles. This figure rose to 1,900 for the day following the upheaval.

Normal Long Lines circuits serving Los Angeles number about 45, but 30 more were speedily set up to handle the emergency business.

Once more we are indebted to press reports for indications that the telephone always is prepared to live up to its purpose of serving anyone, anytime, anywhere, and do it quickly. Two telephones in the White House, one of them handled by Mrs. Roosevelt, kept the President in direct touch with the situation. In New York, former President Hoover talked with members of his family to learn of their safety.

The London *Evening Standard* carried a graphic account of a telephone interview with someone in the quake zone while the tremors still were in progress. Other news dispatches record long distance conversations carried on in the midst of the catastrophe. For example, Walter Winchell, writing in the New York *Daily Mirror,* lets us listen in as he calls his wife:

"Are you all right?" she was asked by her worried husband.

"Yes, but it frightens me a little," came the reply. And then, after a few more words:

"What's the matter?" Mr. Winchell yelled.

"It's shaking again—right now," his wife shouted, "wait till I hold the baby's hand! . . ."

Because it touches a telephone tradition we may pause long enough to quote one more news report. A woman called the news department of *The New York Times.*

"You might be interested," she said, "in knowing that I have just tried to communicate with Los Angeles by telephone. When I had made connection with the Los Angeles operator the girl's voice, calm and unhurried, came over the wire:

"Sorry; I cannot connect you. We're having an earthquake."

* * *

On this calm note we may shift the scene back to Washington just in time to learn that President Roosevelt wishes to speak personally to the nation's citizens by radio in explanation of the fast moving events of his first week in office. And on Sunday night, March 12, the modern communications art put the President within ear-shot of millions of his fellow Americans. Normal facilities of the broadcasting companies were used, 175 stations being connected by 35,000 circuit miles of Bell System wire.

The President's address was a fitting close to the thrill-packed month just reviewed. Within that space of four weeks human qualities of patience, courage and citizenship mobilized themselves in the face of adversity, and seemed to gather in more solid ranks against each new challenge. Several commentators sensed a new neighborliness among Americans. As always, danger and calamity provided the cause for this unity of thought and spirit. It seems equally true that the communications art furnished the means by which a widely scattered people were able to face common problems and perils with a new accent on the "we."

Undoubtedly, new history has been in the making. But from the telephone standpoint it was history repeating itself, under a new set of circumstances. It is evident that mankind in doubt and distress once more found Bell System facilities and personnel ready with the aid that perhaps was needed most—the swift interchange of thought and information which rallies confidence in an emergency as ably as it normally ministers to the social and business needs of the nation.

H. D. Hocker

A New Service for Business Establishments and the Household

THE Bell System has made available a new service arrangement which is particularly well adapted to the telephone needs of moderate size business establishments and households where a number of telephones can be used to advantage. This new service does not require a switchboard or an attendant to handle the connections. These connections are all under the control of the user of each of the telephones by means of keys located in the base of the compact and attractive hand set telephones provided with the service. The keys are easy to operate and their functions simple to understand.

The new service provides for either one or two outside, or central office lines and as many as eleven telephones may be provided. The features of the service may be briefly described as follows:

Each telephone may make or receive outside calls.

Likewise, each telephone may make inside (intercommunicating) calls to or receive such calls from all the other stations on the premises; also, signal by buzzer to all other stations.

When one station is connected to a central office line all other stations are locked out, thus ensuring privacy and freedom from interruption.

Incoming calls may be answered at any telephone and transferred to another telephone on the premises, as desired.

One or two conversations over the central office lines and one conversation with another station on the premises can take place simultaneously.

The compactness and good appearance of the telephones and their associated control keys, together with such features as quick intercommunication and the arrangement for ensuring privacy and freedom from interruption on outside calls, make the new service attractive to both business and family groups.

Use in Business Establishments

Figure 1 pictures a typical business group for whom the new service would be appropriate. Such a group might, of course, comprise either a distinct business establishment of moderate size or a number of people associated in a department of a somewhat larger organization.

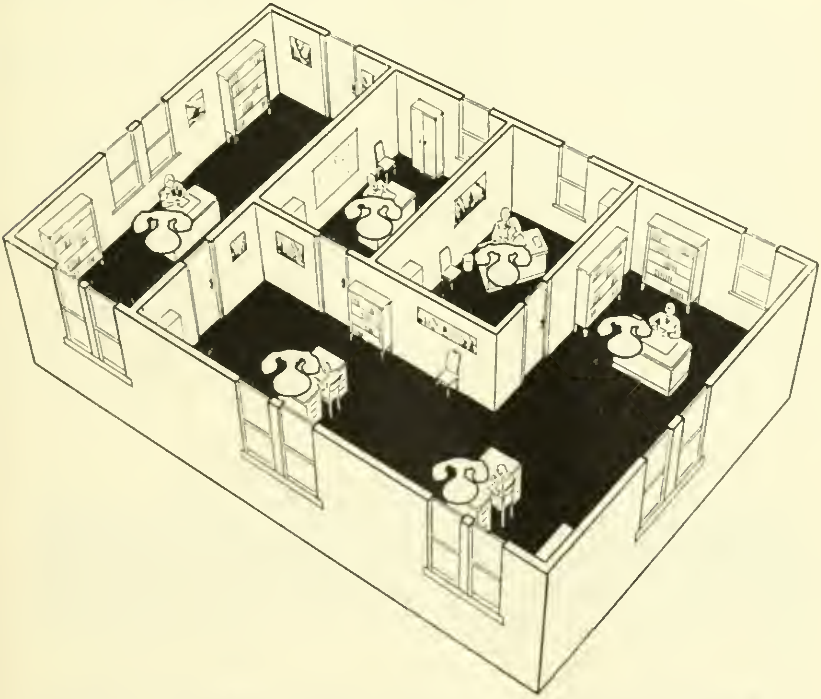

Figure 1. The New Service as Used in the Business Establishment.

In an installation of this kind several features are particularly valuable, such as:

From any of the telephones outside calls can be made or received without the aid of a special attendant.

Each telephone station can intercommunicate directly with any of the others in the office by simply depressing the proper keys.

All other telephones are automatically locked out when an outside line is picked up to make or receive a call, thus providing privacy.

One or more telephones can be restricted to inside intercommunicating calls only, if desired, such as, for example, the telephones in the file or stock room.

If desired, all incoming calls can be answered from any one telephone, such as from the telephone in the outer office.

These incoming calls can be transferred to the proper person at any of the other telephones having key control equipment.

Visitors can be announced directly over the intercommunicating line to any person in the office having a telephone.

IN THE HOUSEHOLD

A typical installation of the new service in a household is pictured in Figure 2 which indicates key control telephones at convenient locations in a detached residence. The advantages

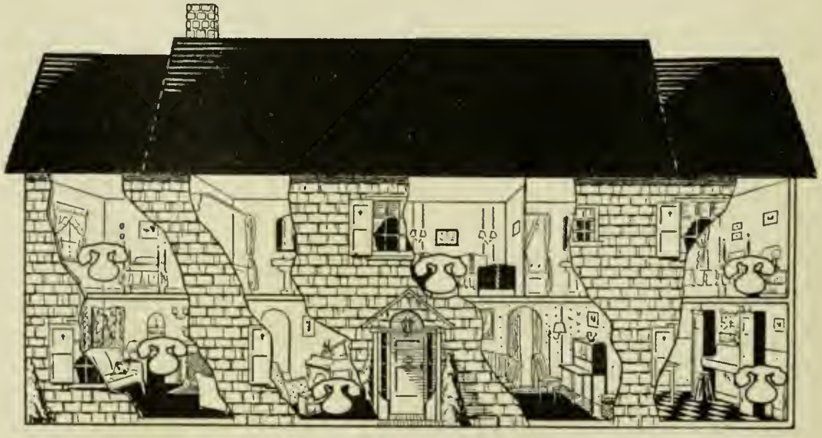

FIGURE 2. THE NEW SERVICE AS USED IN THE HOUSEHOLD.

of the new service from a household standpoint as outlined below would, of course, apply to apartments with corresponding telephone needs.

From the telephone in the bedroom, orders may be given directly to the servants in the kitchen. Likewise, incoming calls may be received or outside calls made with a maximum of convenience.

It helps greatly to simplify the planning of the whole day's program. Saves time and steps and results in a quiet, smooth-running household.

From the kitchen or pantry telephone the interconnecting line makes it easy to check the menu for the day and orders for supplies with the mistress of the household.

The orders may then be given promptly to the tradesmen over the outside line from the same telephone.

From the telephones in the living room and sun parlor, friends may be visited, appointments arranged, and business transacted quickly and comfortably with the assurance that no one can listen in from any other telephone in the house.

From these same telephones, by simply depressing a key, servants can be directed without moving from one's chair.

The guest room telephone is quiet evidence of a modern, well-ordered household. Guests will appreciate the provision of a telephone for their own use.

Operation

A closer conception of the details of operation of this service may be of interest and the principal features, involving the telephone itself, are illustrated in Figure 3. The five keys are marked from left to right, 1, 2, H, L, B, and are used to establish a connection with either one or two central office lines, to hold an outside call while it is being transferred, to connect to the intercommunicating line and to signal other stations.

Incoming calls are signaled by bells—those on the two outside lines being arranged to give different tones to indicate which line is calling. To answer an incoming call one lifts the hand set and presses key 1 or 2, depending on which line is being used, and then talks. Should the call be for someone who can answer more conveniently at some other station, key H is pressed to hold the call, then key L is pressed to connect to the intercommunicating line, and key B is pressed to signal the person or station wanted. Code signaling is usually employed for this purpose. The person at the other station may first answer on the intercommunicating line and the person at the calling line station advises that there is a call waiting on

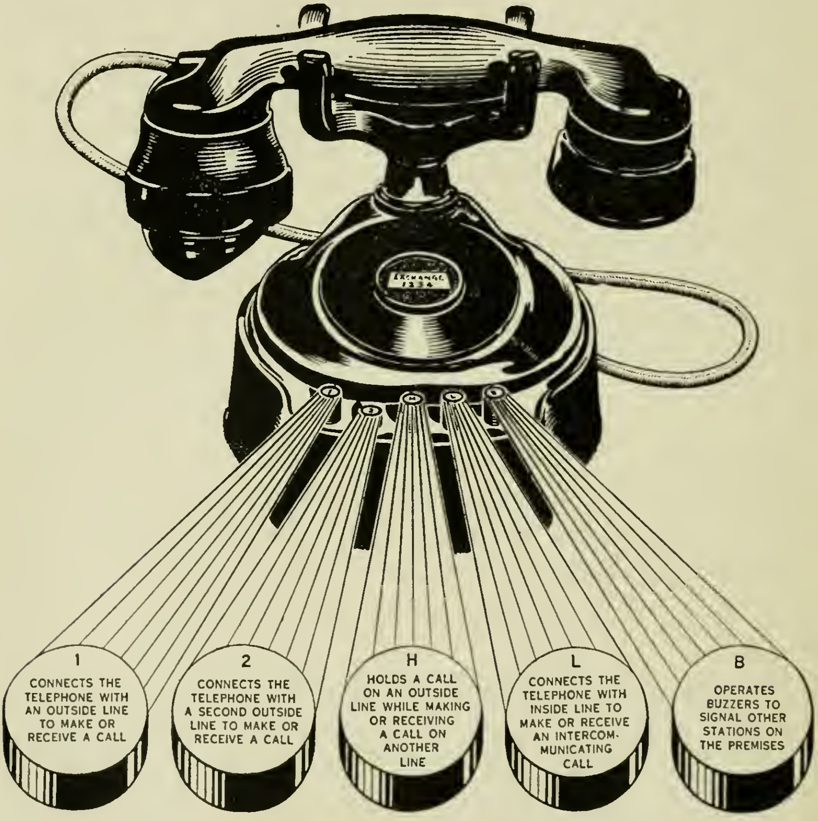
EXCHANGE
1234
1
CONNECTS THE TELEPHONE WITH AN OUTSIDE LINE TO MAKE OR RECEIVE A CALL
2
CONNECTS THE TELEPHONE WITH A SECOND OUTSIDE LINE TO MAKE OR RECEIVE A CALL
H
HOLDS A CALL ON AN OUTSIDE LINE WHILE MAKING OR RECEIVING A CALL ON ANOTHER LINE
L
CONNECTS THE TELEPHONE WITH INSIDE LINE TO MAKE OR RECEIVE AN INTERCOMMUNICATING CALL
B
OPERATES BUZZERS TO SIGNAL OTHER STATIONS ON THE PREMISES

FIGURE 3. HOW KEY CONTROL EQUIPMENT OPERATES.

line 1 or 2. The second station then goes in on the designated line by pressing the key associated with that line and the first station then hangs up, thus making his station available for other calls.

As an optional feature, a small attractive lamp placed near the telephone may be employed to indicate a busy outside line. For example, if a person should press key 1 to make a call and line 1 was busy, the lamp would light, and he would then place his call on line 2. A single lamp is employed for indicating a busy condition on both lines, associating itself automatically with the line corresponding to the button pushed.

The relays and other equipment required for the switching features controlled by the keys in the telephones are contained in two small wooden cabinets having mahogany-walnut finish. These cabinets can, of course, be placed in an out-of-the-way location.

The new service described in this article is provided by what are known to telephone people as the "No. 15-A and No. 23-A Key Equipments." These equipments are of the same general type with respect to operation and station equipment as the 750-A Private Branch Exchange, but are arranged to meet the requirements of smaller installations and where the need for intercommunication is less. The 750-A Private Branch Exchange was described in the October 1930 Bell Telephone Quarterly, in an article entitled "An Intercommunicating System for Homes and Offices."

C. J. Davidson

Lightning

Editor's Note:

Storms and storm damage have been frequently described in the BELL TELEPHONE QUARTERLY *but always from the standpoint of the emergency created and of the accomplishments of the telephone forces in restoring the service for public use. The following article discusses storms and storm phenomena from another point of view, that of cause instead of effect. Though necessarily technical in character, it will be of interest to non-technical readers as evidence of the continuing study of storms in the Bell System and their effect on telephone service.*

INTRODUCTORY

BECAUSE of its magnificence and grandeur, lightning with its sudden and uncontrollable outbursts of power has always been an object of admiration as well as awe. No wonder that in the ancient days, when the gods were associated with visible objects such as land, sea, trees, and the heavenly bodies, lightning was supposed to be the special weapon of mighty Jove himself. Even up to modern times, lightning was widely regarded as a sign of divine displeasure and attempts to escape its baneful effects were decreed sacrilegious.

While lightning is no longer regarded as anything but a natural phenomenon governed by the immutable laws of physics, still because it is mysterious in character and unique in aspect while yet directly related to our daily life, lightning is a subject of widespread interest and even curiosity. To telephone people lightning presents a practical problem, for it is capable of producing serious effects on communication service, either by damaging overhead lines and their connected equipment or by disturbing the transmitted signals.

Geographical Variation

Lightning occurs all over the world, both on land and sea, but its distribution is very non-uniform. In the United States some regions have a hundred times as many thunder storms as others, the area of most frequent occurrence centering around northwestern Florida where there are on the average about ninety thunder storms per year. Severe lightning is also experienced in the northern New Mexico and southern Colorado area where the average number of thunder storms per year is about seventy. In the vicinity of New York City the yearly average is about thirty, while around San Francisco it is only one. Lightning is much more severe in some thunder storms than in others, but nothing indicates that on the average the storms occurring in different localities differ much in severity.

Development of Protection

If Benjamin Franklin had never done anything else, he would have immortalized his name by his famous kite experiment of July 4, 1752, by which he showed that lightning is electrical in character. At that time electricity was known only in its static form, it being forty-four years later when electric current was first produced from batteries and seventy-nine years later when the principles underlying the production of currents from inductive mechanisms were experimentally demonstrated.

Up to the latter part of the nineteenth century investigations in this field were concerned chiefly with the problem of protecting buildings by lightning rods according to the method proposed by Franklin. Since that time lightning investigations have been largely from the standpoint of developing protection for electric power and communication systems. The storage in large quantities of oil, gas, and explosives has also brought about special and difficult problems in lightning protection.

Modern Investigations and their Results

Lightning studies in recent years have made use of a number of devices and methods unknown to earlier investigators. One such instance is the simulation of actual lightning by controlled electric discharges at from one million to ten million volts. In the laboratory this method has yielded valuable information about the formation and behavior of long arcs in air. It has also been employed for test purposes on high voltage transmission lines. However, as the controlled discharges are necessarily on a reduced dimensional scale, care has to be exercised in applying the results to natural lightning conditions.

An instrument called the "klydonograph" has been extensively used, because of its simplicity, for securing figures of lightning surge voltages which indicate the magnitude, but not the duration, of the surge. Specimen records obtained by this instrument are shown in Figures 1 and 2. The magnitude of the voltage is indicated by the size of the light spot and the aspect of the figure tells whether the voltage was positive or negative.

Until recently, there has been no way to measure the time which a surge of lightning voltage takes to grow from zero to its maximum value, or the time required for the surge to disappear. In more technical terms, the steepness of wave front of the lightning surge, and the length and shape of its tail, were not definitely known. The cathode ray oscillograph has now been developed to a point where it can be used to record the changes in the lightning voltage during the period of the surge. Figure 3 shows a typical lightning voltage curve, as derived from records obtained by this instrument.

The magnitude of current in a lightning stroke has heretofore been unknown except by rough estimates of doubtful reliability. An instrument called a "surge-crest ammeter" has recently been devised which, it is hoped, will enable dependable measurements of lightning current to be made. Another recent device is the "storm severity meter" which

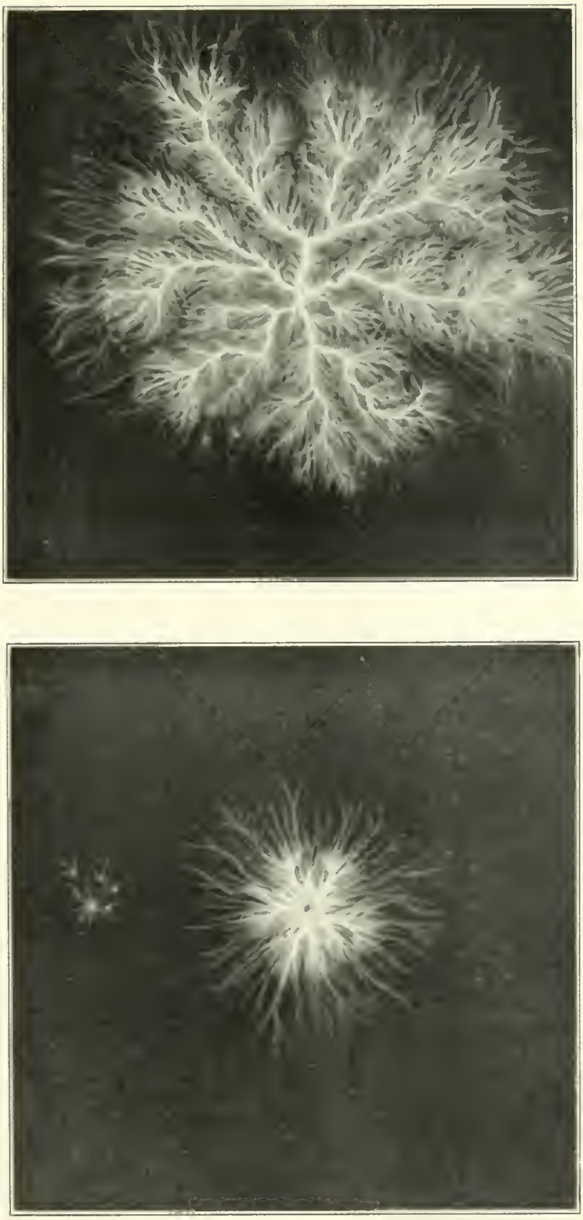

FIGURE 1. POSITIVE KLYDONOGRAPH FIGURES.

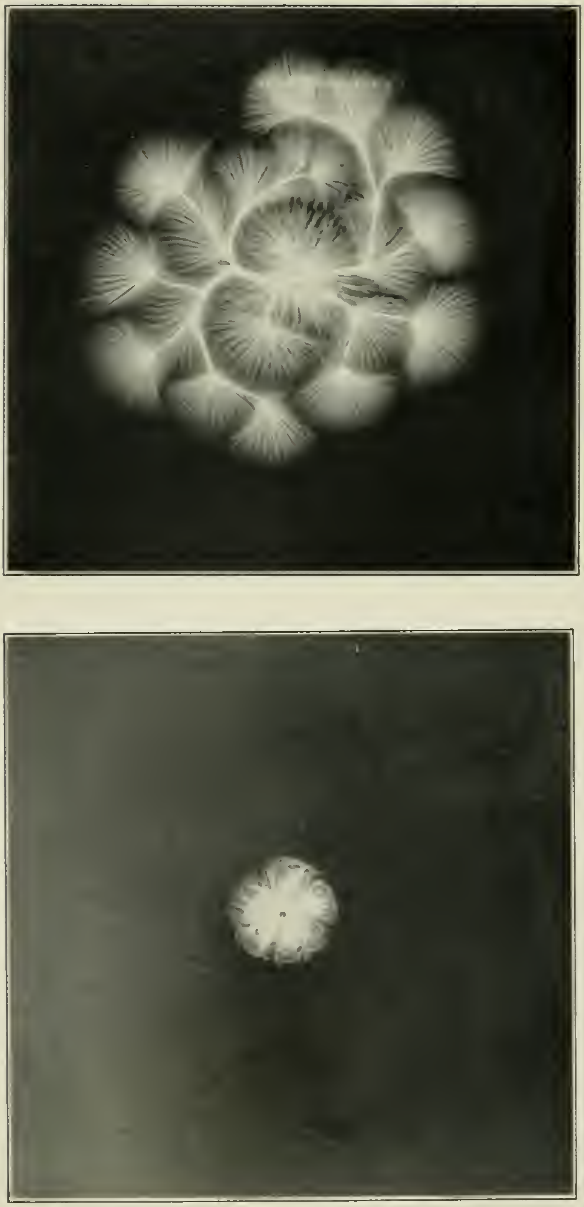

Figure 2. Negative Klydonograph Figures.

makes a sort of integrated record of lightning intensity, through successive short intervals of time.

During the last decade there has been much intensive research on lightning and it might be supposed that the subject is now well understood, but this is not the case. To say, paraphrasing Professor Shapley's quip on "Corpuscles," that knowledge concerning lightning has grown so rapidly in recent

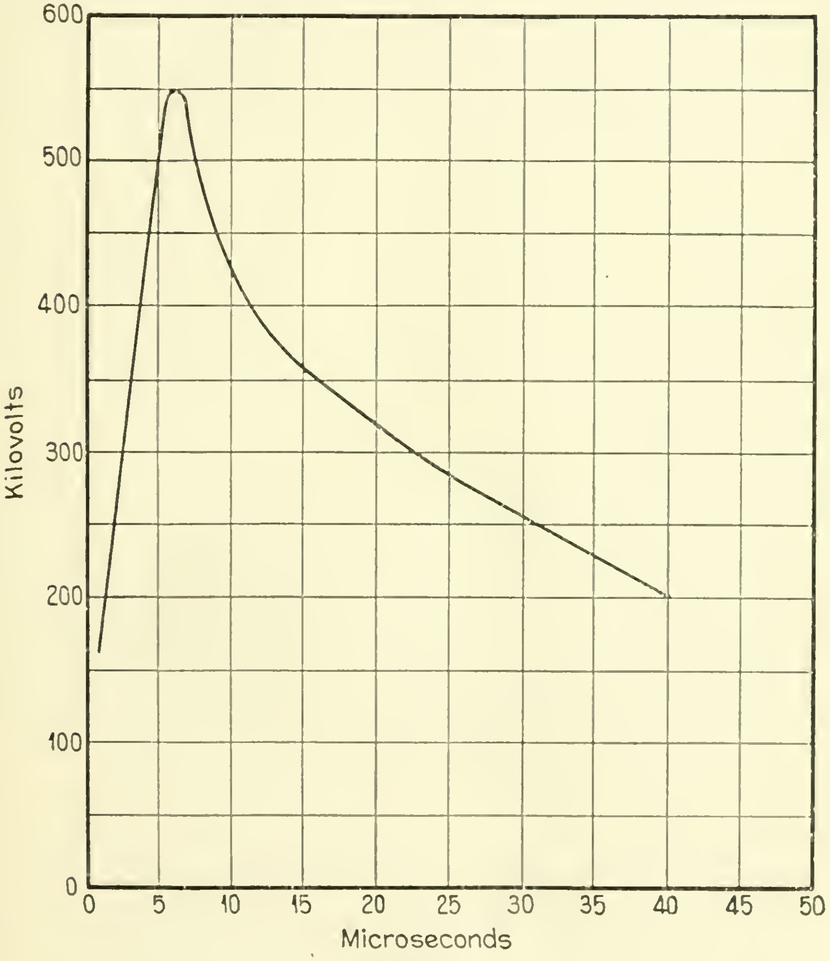

FIGURE 3.

years that now we know practically nothing about it, would be going too far. While there is no other electrical phenomenon of the magnitude and character involved in lightning, by experience with which we may be guided, still, by compounding the results of field tests and laboratory experiments, direct observations, fragments of fact, a little theory, and a few modest assumptions, we arrive at a conception of lightning which perhaps is not wholly erroneous.

The Atmosphere

Lightning is a spectacular actor and the theatre of its performance is the lower portion of the earth's atmosphere, called the "troposphere." The atmosphere is a mixture of gases, a tenuous expanse of atoms, molecules, and other minute particles, darting rapidly in all directions, now and then colliding with one another.

Pure, dry air, at the earth's surface is composed of about 78 parts by volume of nitrogen, a little less than 21 parts of oxygen and slightly less than 1 part of argon, with small amounts of carbon dioxide, hydrogen, neon, helium, and other rare gases. The air, however, is not normally dry but contains water vapor in amount varying with climatic and weather conditions but averaging about 1.2 per cent. The air also contains ordinarily a small amount of solid material in the form of fine dust.

The atmospheric gases are prevented from diffusing into space by the earth's gravitational attraction. The air pressure at any point is the weight of the vertical column of air above it of unit cross-sectional area, and falls off with increasing altitude from a value corresponding to about 30 inches of mercury at sea level, to less than one-thousandth of 1 per cent of that value at an altitude of 100 miles. As water vapor and dry air do not have exactly the same weight, the barometric pressure is somewhat affected by the degree of humidity.

When the air becomes saturated, that is, when the limiting amount of water vapor at the existing temperature, is reached, some of the vapor condenses into minute water droplets. These may coalesce and fall as rain or, if small enough, may remain suspended in the air. A cloud or fog is an aggregation of such suspended droplets.

Anyone who is afraid of lightning can find a region free from it by ascending vertically into the air about seven miles where he will find himself at the base of the region known as the "stratosphere." The composition of the air at this point is about the same as at sea level, except that there is no appreciable amount of water vapor. The pressure has decreased to about one-fifth of its sea level value and the temperature has fallen to about — 65° F., about 17° F. drop per mile of altitude. If our timid friend should ascend still higher, he would find that while the pressure of course continues to decrease, the temperature remains substantially the same, — 65° F. for he is in the isothermal belt. Since there is no moisture in this region, there can be no rain or snow. Thunderstorms and lightning are phenomena involving moisture and are limited to the lower atmosphere or troposphere.

In addition to the particles above mentioned, the earth's atmosphere contains important forms of energy. Light and heat are transmitted to us from the sun and stars by means of high frequency electromagnetic radiation. All rays which reach the earth proper, including the cosmic rays, must of course pass through the atmosphere, as must also radiation from the earth to outer space.

Electromagnetic rays are understood to consist of streams of minute corpuscles called "photons." Such rays pass freely through space at the velocity of light, but their motion is interfered with when they strike a material body or even a small particle like an atom, their impingement on such body or particle exerting a mechanical force. The pressure exerted upon the earth by solar radiation amounts to about 100,000 tons, which corresponds to about one ounce of repulsive force per 50,000 square yards of surface normal to the radiation.

IONIZATION

The formation of electric charges in clouds and the sudden dissipation of these charges which constitutes lightning, are intimately concerned with an electrical process known as "ionization." The term "ion" was invented a century ago by Faraday to designate one of the charged particles in an electrolytic cell, half of which are positive and travel in one direction, the other half negative and travel in the opposite direction, when current passes through the cell between its two electrodes. It is now known that the earth's atmosphere also contains ions and that under some conditions they are very abundant in certain regions. The smallest known ion is the "electron," which carries one elementary negative charge and may roughly be regarded as an "atom of electricity." A particle having its normal quota of electrons is electrically neutral but on losing an electron, it acquires a positive charge equal in magnitude to the negative charge of the electron.

Ions are produced in many different ways. They are found in solutions of metallic salts. They are shot out from the heated filaments of vacuum tubes such as are used in radio sets. They are emitted spontaneously in the atomic disintegration of radium and other radioactive elements. Streams of electrons expelled at high speed from the disintegrating atoms of radium constitute the so-called "beta rays." Radium also emits "alpha rays" which are streams of helium atoms positively charged, each atom lacking two electrons. A helium atom corresponds in mass to four hydrogen atoms and a hydrogen atom minus an electron constitutes a "proton," carrier of unit positive charge and smallest known positive ion, although 1,800 times as massive as the electron.[1]

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[1] The discovery of a corpuscle having the same mass as the electron but with unit positive charge instead of negative, has recently been reported. If the existence of such a free positive corpuscle is confirmed by further investigation, it may be

Of the radiation from the sun which reaches the earth's outer atmosphere, it is estimated that about 1/3 is lost by scattering and reflection into space, 1/3 is absorbed in the atmosphere, mostly in the highly rarefied region of the outer atmosphere, and 1/3 reaches the earth proper, most, if not all of which is later reradiated. The absorption of radiation is one of the causes of ionization of the air. The impingement of cosmic rays, rays from radioactive substances, and solar rays, particularly rays in the ultraviolet range, upon molecules or atoms in the atmosphere, not only reacts on the rays but releases ions from the atoms. Also an ion moving at more than a certain critical speed, by colliding with an atom or molecule, may dislodge therefrom another ion. Ionization of the atmosphere is also produced by meteors which are continually bombarding the earth, but these are for the most part dissipated before they have penetrated far into the outer atmosphere. Also it has been found by laboratory tests that ionization is produced when drops of water are broken up by an air blast, electrons being liberated or taken up by the smaller particles while the larger droplets are left positively charged. This action, which apparently is a form of frictional electrification, is thought to play an important part in the production of electric charges in clouds.

Moisture in the air tends to collect around particles of dust and free ions have a tendency to attach themselves to the water droplets. It is believed that solar radiation, insofar as it is absorbed in the lower atmosphere, is mostly expended by charging particles of moisture. Under the influence of high electric potentials, free ions are capable of moving at enormous speeds, but when such an ion becomes attached to a relatively enormous water droplet to form a large ion, it loses much of its mobility. Since the electric conductivity of air depends

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called a "positron," and the present electron renamed "negatron," the significance of the word "electron" being changed to include either negative or positive free corpuscle.

upon the mobility of ions, moist air is less conductive than dry air. Similarly free electrons increase the conductivity of air more than free protons and small ions more than large ions, since the latter have less mobility.

Thus we visualize the lower atmospheric space as populated by corpuscular bodies or particles, some positive, some negative, but most of them, normally, neutral. The negatively charged particles include free electrons, small ions or clusters of atoms and molecules, and large ions, i.e., water droplets or other minute bodies, having an excess of electrons. The positively charged particles include free protons and small and large ions which are deficient in electrons.

There is an increase in electric potential with increasing altitude, the potential gradient diminishing with the altitude and also varying from time to time and from place to place, but averaging near the earth's surface about 30 volts per foot. Thus a mile in the air, the potential is ordinarily about 100,000 to 150,000 volts above earth potential. There results a gradual and continuous movement of ions up and down through the atmosphere, from and to the earth, the prevailing direction of ion movement being that corresponding to the loss of negative ions by the earth. This ion movement corresponds to a current to the earth of about 1,000 amperes average value which is compensated for by reverse transfer of ions by lightning, rain, convection, and other agencies.

Electric Condenser

In considering the formation of electric charges in clouds, it is useful to employ the concept of the electric condenser. Essentially a condenser consists of two conductors, e.g., a pair of parallel metal plates, separated from each other by insulating material, which may be air. These two conductors form the electrodes of the condenser, and if connected to a battery or direct-current generator, become charged, i.e., negative ions pass to one electrode and positive ions to the other. If the condenser has only small capacity, the migration of a relatively small number of ions, or in other words, the formation of relatively small charges on the electrodes, will make the potential difference between the electrodes equal to the voltage of the source of supply, at which time the flow of ions, i.e., the current, will cease. With a given condenser the number of ions which must migrate before the condenser is fully charged, is proportional to the voltage impressed upon it. If, however, too much voltage is impressed on the condenser, the air-gap or insulation between the two electrodes will break down, and there will be for an instant a violent rush of ions forming a spark channel through the insulation at the point of breakdown. This rush of ions quickly dissipates the charges and brings the two electrodes to the same potential.

In analogous fashion a cloud may be considered as constituting one electrode of a condenser, the earth beneath constituting the other electrode, the intervening air being the insulating material between these electrodes, or the electrodes may consist of two clouds or of different portions of the same cloud. This last case would not be possible if a cloud were a continuous conducting body like a piece of metal, but being an agglomeration of discrete moisture particles, with relatively large air spaces between them, it is possible for one part of a cloud to take on an excess of negative ions while another part of the same cloud assumes a deficit of negative, or an excess of positive, ions, i.e., one part of the cloud becomes charged negatively, and another part positively.

Formation of Charges

We may now consider a theory as to how electric charges in clouds may originate.

The absorption of energy from the sun's rays in different parts of the troposphere is not uniform, but is affected by several factors, one of which is the degree of humidity. The humidity in the atmosphere varies in turn from point to point, depending upon conditions as to precipitation and evaporation from water bodies. The absorption of heat from the sun by a given area on the earth's surface varies with the angular inclination of the sun's rays to the surface, the character of the surface, and with cloud and other atmospheric conditions. The radiation from the earth into the atmosphere is non-uniform because of variations in temperature and in surface conditions. For these various reasons there are at different points in the lower atmosphere, bodies of air of various sizes, shapes, temperatures, densities, and degrees of ionization. These bodies of air, acted upon by gravitational forces, are set in motion, resulting in the well-known phenomenon of winds. Winds at the earth's surface are predominantly in a horizontal direction, but it is important to note that in the cloud regions, air currents may have strong vertical components.

Thunder clouds are characteristically of the cumulus type, i.e., they resemble a pile of granular material. Their formation suggests strong local air currents directed vertically upward. Thunder storms commonly occur on hot, humid days. Vertical air currents mean that heated air masses near the earth are rising to the cooler upper regions. As lower temperatures are reached, particles of water condense from the water vapor. The water droplets so formed gradually coalesce until they become drops too big to be longer supported by the upward air current, when they start to fall. When the relative velocity of the falling water drops and the rising air current reaches about 25 or 30 feet per second, or whenever the drops encounter sudden gusts of wind, they become blown apart into fragments. The breaking up of the water drops produces, as already stated, positively charged moisture particles, and electrons either free or attached to the smaller water particles. The latter being lighter are carried upward by the rising air current and become attached to water droplets in the higher regions of the cloud. The heavier positive particles merge with water droplets in the lower portions of the cloud. Thus the lower part of the cloud becomes charged positively, the upper part negatively.

When the lower part of a cloud becomes charged, a charge of opposite polarity is induced on the earth's surface directly below. (The term "earth" should be understood to include objects on the earth's surface even though they are normally insulated.) If the cloud charge is positive, the charge on the earth's surface directly below the cloud will be negative, as the positive charge on the cloud attracts negative ions from more remote parts of the earth.

Just as the application of voltage (difference of potential) to a condenser, produces a charge on each electrode of the condenser, so the existence of electric charges of opposite polarity on the electrodes of a condenser, means that there is a difference of potential between the electrodes. If, therefore, the lower part of a cloud is charged, and the earth's surface directly below the cloud is charged oppositely, there must be a difference of potential between the cloud and the earth. As a matter of fact the difference of potential between a thunder cloud and earth may be enormous. When such potential difference reaches a value higher than the intervening air can withstand, there is a breakdown of the insulating air and a lightning stroke occurs, which is nature's way of relieving the excessive stress.

If we should explore the potential variation along a vertical line between the bottom of a cloud and earth just prior to a lightning stroke, it would be found that the fall in potential through the air is not uniform. The gradient (potential drop per foot) would be found to have at some point, a value much greater than the average. Observations indicate that the maximum gradient usually occurs at some point in the lower fringes of the cloud, but this is not always the case. Also the more intense the ionization at any point along the path between cloud and earth, the less the potential gradient required to start breakdown. When the gradient at any point becomes as much as about one million volts per foot (or less if the ionization is strong) a spark or streamer will be initiated, indicating incipient rupture of the air. This streamer, producing most intense local ionization as it advances, is the initial stage of a lightning stroke. It indicates a highly condensed stream of ions passing at enormous velocity through a narrow channel rendered incandescent by the heat generated. The course of the discharge is usually very irregular since it is determined by the distribution of ionization and gradients along various paths between the cloud charge and the earth charge. A stroke often divides into several branches, some of which may die out before reaching earth if the advancing ions meet a body of bound ions of opposite polarity or diffuse to form a space charge.

In the simplest case of a lightning stroke to earth, half of the excess positive ions in the cloud pass to earth through the lightning channel, and conversely, half of the excess negative ions causing the earth charge, pass to the cloud, thus restoring equilibrium at least momentarily. The first transfer of ions between cloud and earth, however, is usually not just sufficient to neutralize the charges, and a second or third transfer may follow, i.e., several discharges may occur in rapid succession through the same channel.

Myriads of separate water droplets in the cloud, have to give up individually their positive ions to the lightning channel, and likewise receive negative ions from the channel, a process which requires appreciable time. Thus due to the time required for discharge, assuming a given charge in the cloud-earth condenser, the current of the lightning stroke is smaller than it would be if conditions were such that the charges could be dissipated more quickly.

The foregoing attempts to picture roughly an ordinary cloud charge formation and dissipation, but it is not to be supposed that the actual event is always so simple. The turbulence of the atmospheric gases in thunder storms often results in violent upheavals of the cloud masses, with charges of polarity opposite to that described, so that a lightning stroke may represent dissipation of a negative cloud charge and a positive earth charge. The evidence as to the relative frequency of occurrence of positive and negative strokes is incomplete. Reports of laboratory tests with high voltage discharges between a metal sphere as a positive terminal and a grounded metal plate as a negative terminal, state that the stroke was found to start as a single stem from the positive pole and usually to split into several branches before reaching the negative pole. Such a discharge bears a striking resemblance to natural lightning from cloud to earth, which usually starts from the cloud as a single stem and forms ramifications before reaching the earth. This is consistent with the view that lightning usually results from a positive charge on the cloud. Other investigations of the polarity of lightning indicate that, while positive discharges from cloud to earth are more numerous than negative discharges, the latter are generally more severe. With either polarity it is believed that the discharge is usually initiated in or near the cloud. In rare cases the branching is towards the cloud, which may indicate a stroke initiated at the earth, but this is mere speculation.

When lightning strikes from one part of a cloud to another part, or from one cloud to another, potentials to earth may be set up by induction. Also a discharge between cloud and earth, produces secondary effects in the vicinity by induction. It was formerly supposed that induced voltages were an important cause of damage by lightning, but now it is believed that most injurious effects are caused by direct strokes.

Wave Shape and Other Characteristics of Lightning

Lightning strokes do not represent currents changing direction back and forth, but are non-oscillatory in character. The reason they behave like very high frequency discharges is that the lightning surge has a very steep wave front. Records of lightning surges by cathode ray oscillographs on power transmission lines show that the voltage rises to its maximum at the rate of from 10,000 to 15,000 kilovolts per microsecond (one millionth of a second). The voltage falls off much more slowly, requiring from 10 to 100 microseconds to decrease to half its maximum or crest value (see Figure 3). If it were possible to make a record of a lightning surge wave front, without allowing the recording arrangement itself to affect the surge, the wave front would doubtless be found to be even steeper than these curves indicate.

Photographs taken with a rotating camera show that a lightning surge, which to the visual observer appears as a single flash, is really a sequence of surges following one another at intervals of from 1 to 10 thousandths of a second.

The effectiveness of a grounding connection to a lightning arrester is not indicated by its resistance to direct current or low frequency alternating current, but depends on its surge impedance. These two quantities, surge impedance and resistance, may differ widely, the former being largely determined by factors which do not affect the latter. For example, a coil of insulated wire spread out on the ground may, by reason of its capacity to earth, have a low surge impedance and constitute a good grounding connection for lightning, although being useless as a grounding connection for such frequencies as are used for commercial purposes.

Energy of Lightning Stroke

During its brief duration, a lightning stroke develops enormous power. The potential of a typical stroke may be a hundred million volts and the current, 200,000 amperes, corresponding to perhaps twenty billion horsepower. If the duration of the surge is 50 microseconds, this would mean some 200 kwh. of energy. These figures are very rough and intended merely to indicate the order of magnitude. Fortunately an object struck by lightning receives only a small percentage of the total energy of the stroke, most of the energy being dissipated in other parts of the lightning path.

AREA AFFECTED BY A STROKE

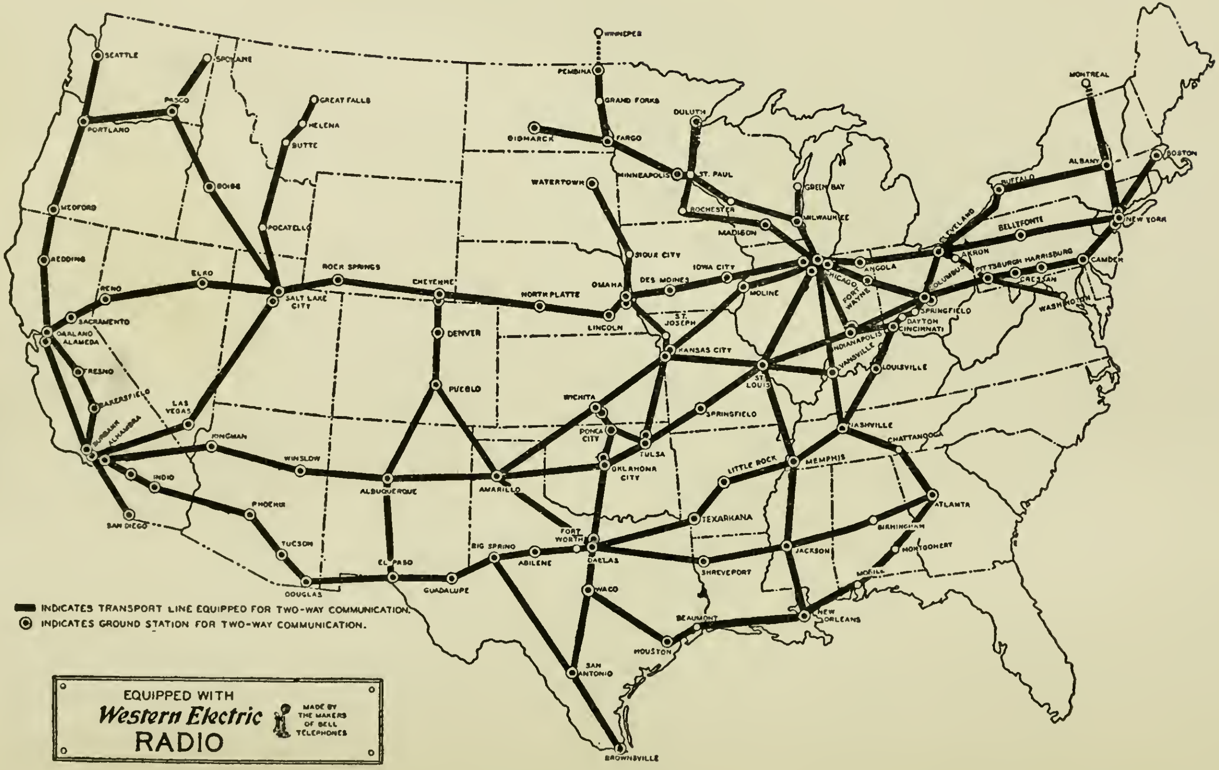
The area affected by a single lightning stroke, or by a single ramification in case of a branched stroke, is not large. Inductive effects at distances of 100 feet or more from the lightning channel are seldom severe enough to cause damage. Sometimes however, over ledgy or other high resistance formations, lightning will plow along the surface of the ground for a considerable distance before the charges are dissipated.

AURORAS AND TERRESTRIAL MAGNETISM

As auroras are also electrical manifestations in the atmosphere, it might be supposed that they have some relation to lightning. However, there is no apparent connection between the two phenomena. As stated above, lightning is confined to a zone within a few miles of the earth's surface, whereas the lowest parts of auroras are at an altitude of fifty miles or more. There is however, a very direct relation between auroras and earth currents and earth magnetism, indicating that the electrical influence, whatever it may be, of which the auroras high in the upper stratosphere are a visible manifestation, does penetrate the troposphere and doubtless affects it to some extent.

Methods of protection against lightning and the degree of success experienced in their practical application will be discussed in a later article.

HOWARD S. WARREN



▬ INDICATES TRANSPORT LINE EQUIPPED FOR TWO-WAY COMMUNICATION.
◉ INDICATES GROUND STATION FOR TWO-WAY COMMUNICATION.

EQUIPPED WITH
Western Electric
RADIO
MADE BY
THE MAKERS
OF BELL
TELEPHONES

Communications and Commercial Aviation

ISOLATION. That is the impression that the passenger generally feels most vividly when, for the first time, he sits in a transport plane apparently suspended between earth and sky and watches fields and farms, rivers, roads and towns pass slowly beneath. In clear weather the sense of speed is almost wholly absent. With the roar of the engines ever in the background, the passenger knows that the plane is moving at perhaps a hundred and twenty miles an hour. He knows it, but he is not conscious of it. Rather, he views the scene spread out below him like a topographical map with the calm detachment of a visitor from another planet. He feels remote from mundane clamor, aloof, alone with the small group in the plane, cut off from the myriad voices of earthbound humanity.

Not so the pilot. For he or the co-pilot is in constant communication with the world below.

He glances at his clock. It is almost time for a call from the ground. He notes his altitude, position and weather conditions in preparation for the expected call. A moment more and, right on the dot, there comes a voice out of the empty air: "Cleveland to eighty-four ninety-three. Go ahead." And the pilot answers: "Eighty-four ninety-three to Cleveland. Position is 15 on the course. Altitude 3000. Ceiling unlimited. Visibility 10 miles. Go ahead." The Cleveland dispatcher repeats the message. It is a routine report which the pilot makes to his ground stations at regular intervals. He has received word from the ground station to proceed, very much as a railroad train passes from one signal block to another.

At stated intervals our pilot will be called again. In the meantime, over his long wave receiver he will get spoken reports from government weather broadcasting stations.

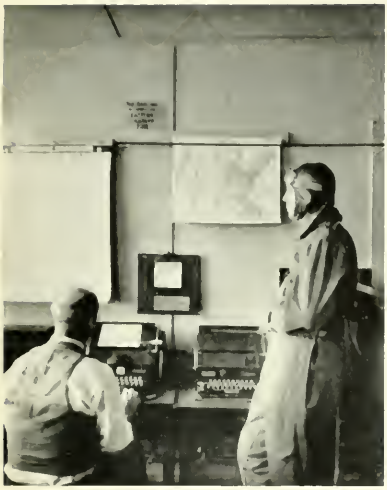
Over his two-way system he will hear reports from other planes and may under favorable conditions talk directly to them if desirable. And at any time he can call one or more ground stations.

Sometimes he does. A case of acute appendicitis developed on a transport plane some time ago. The stewardess did what she could to aid the afflicted passenger and the pilot called the airport at which he was about to land. An ambulance was summoned and arrangements made to receive the patient. The radio telephone in the plane proved its worth in that emergency, as the telephone in the home has so often done.

Or again, suppose a sudden fog develops somewhere along the line. The pilot of the plane in the affected area immediately calls his ground station and reports the condition. The dispatcher instructs the pilot to go around or over the bad spot or, if conditions warrant, he orders the plane to land at the nearest field. Along the charted airways regular or intermediate landing fields are never far away. Furthermore, the dispatcher calls the other planes in his territory which are approaching the fog area, warns them of conditions and issues suitable instructions.

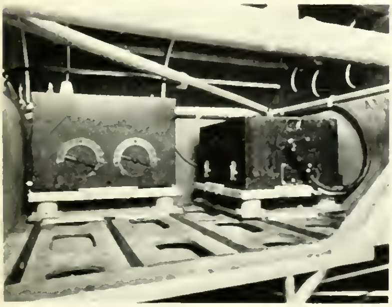
This, then, is two-way aviation communication in action, a Bell System development which has added tremendously to the safety of air travel.

For the sake of clarity, the contributions which the art of communication has made to commercial aviation may be grouped under several heads. First, there is two-way high frequency radio telephone communication between airplanes and the ground. This may be subdivided into (*a*) air transport company two-way dispatching and (*b*) airport and itinerant flyer two-way communication. Second, government weather broadcasting and range beacon signals and their reception. Third, the use of the teletypewriter service by the Government primarily in making exact knowledge of weather conditions quickly available and in posting up-to-the-minute



The Teletypewriter Brings Weather Reports to the Aviator Before he Leaves.

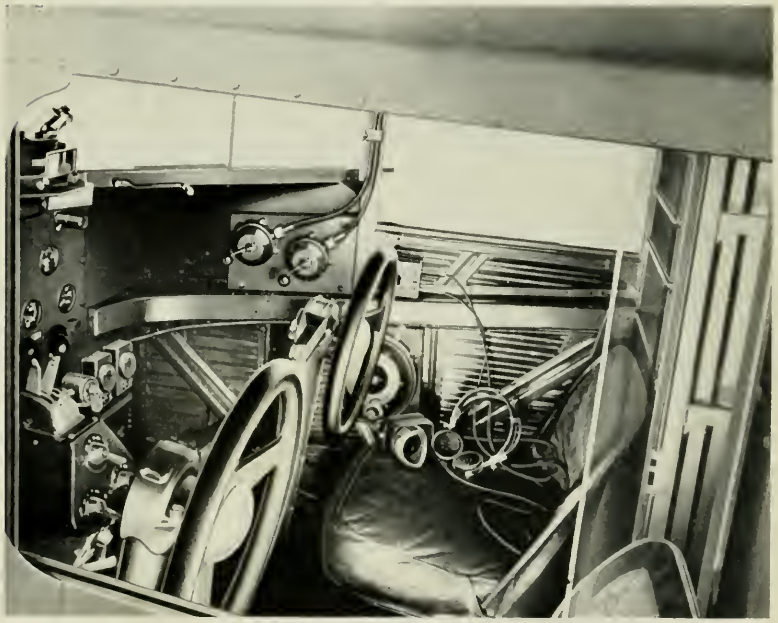
The Pilot in Flight Can Talk to the Ground Station.



Radio-telephone Equipment for the Private Flyer Installed in Plane.

The Ground Station Can Talk to the Pilot in Flight.

Ford Tri-Motor Airplane used in Bell Telephone Laboratories Experiments.



Pilot's Cabin of Bell Laboratories' Ford Tri-Motor Airplane.

weather maps along an entire airway. Fourth, the use of teletypewriter service by air transport companies in connection with their operations.

It was in the spring of 1929 that the Western Electric Company and Bell Telephone Laboratories first demonstrated two-way radio telephone communication between airplane and ground for commercial air transport service. However, the Bell System's development work in this field dates back to World War days when the Western Electric Company turned out hundreds of airplane radio telephone sets. Experimental work was subsequently continued. About four years ago a five-seater monoplane was purchased by Bell Telephone Laboratories and later a trimotor plane of the transport type. In order to base the design of commercial radio telephone apparatus on a foundation of practical experience, test flights were made from Hadley Field, using the Laboratories' experimental transmitting station at Whippany, New Jersey. Other flights were made in California, using a transmitter at Oakland. Based upon these tests and upon continuous research combined with experience acquired through intimate contact with the aviation industry, designs were made and apparatus manufactured. Equipment embodying many fundamental improvements over the commercial units placed in service in 1929 was brought out in 1932. Many of the new sets are now in use. They will make for even greater reliability in operation than the earlier apparatus used by air transport companies during the previous three years.

To each air route a pair of frequencies are assigned; one of each pair in the 5 megacycle band for use by day, the other in the 3 megacycle band for night operation. Remote control quick shift gear permits rapid shifting from one frequency to the other by planes while in flight. To prevent interference, a schedule is set up so that each station will have exclusive use of the channels for a few minutes. By a glance at the special dial-face of his clock, the dispatcher can see when he may go on the air to call planes in his vicinity. Plane transmitters operate, of course, on the same frequencies. When the pilot wishes to talk, he pushes a button mounted on his microphone which energizes his transmitter.

To override the plane noises a fairly loud signal must be delivered to the pilot's headphone. For this purpose the Bell Laboratories have developed a headset with a receiver using a special diaphragm which gives great protection against static crashes while not interfering with the desired signal. The pilot's headset is connected to both the two-way and the beacon receivers. The equipment is arranged so that the beacon receiver can be operated separately from the two-way communication system. This permits one pilot to listen to the range beacon while the other is listening to the ground station, or one or both pilots to listen to the receivers desired. Separate volume controls enable the pilot to listen to one receiver while having the other just above the threshold of audibility. Should a call come on the latter, a flip of the two control knobs will bring it in and soft-pedal the other, so to speak.

Keeping all these transmitters—in airplanes and ground stations—on their assigned frequencies is quite an accomplishment. If it depended on the stability of coils and condensers, as in the earlier broadcasting sets, communication would no doubt be handicapped by a deviation of several thousands cycles. To obviate that, all Western Electric transmitters are equipped with quartz-crystal oscillators. In each, a tiny slip of what looks like ground glass is adjusted and sealed into a holder. Its function is to hold the frequency of the transmitter within at least .025 per cent of what it is supposed to be. When a pilot's receiver has been tuned in at the starting point, it does not have to be tuned again during his run; and the dispatcher's set can receive from any plane in his division.

For the itinerant flyer the Western Electric Company manufactures apparatus that weighs only about 30 pounds for the one-way equipment, or 65 pounds for the two-way system. Through co-operation with airplane builders, virtually all radio-equipped planes now have the units installed at the time of manufacture—an arrangement with obvious advantages from the standpoint of efficient operation, economy and appearance.

So much, then, for two-way communication. It is the most recent aviation communication development. Dovetailing with it are the Federal government weather broadcasting and range beacon services, augmented by teletypewriter wire systems.

The air navigation act of 1926 provided for the establishment by the Government of airways throughout the United States. The work has progressed rapidly and there are now 19,500 miles of lighted air-routes, equipped to furnish weather reports and range beacon signals. Through his long wave receiver, operating in the range of 230 to 500 kilocycles, the pilot may hear the rhythmic beat of the directional range signals. These signals form, as it were, an aerial pathway between beacons. So long as the pilot is on his course, he will hear a continuous tone, made up of a series of long dashes. If he should drift to one side, the accent of the directional signal would change. " Dot Dash " would be the sound. Or, if his drift were in the opposite direction, " Dash Dot, Dash Dot " would be the insistent warning conveyed through his headset. Along the established air routes the pilot is never out of earshot of this automatic transmission, which is interspersed with the identification signal of the station and is interrupted, periodically, by an oral announcement from the station giving an up-to-the-minute weather report. The radio receiver for such service must obviously be light, compact and rugged. Since it, like the other units, is operated by remote control, it is possible to locate it in an out-of-the-way place in the plane. Nevertheless, it may readily be removed from its mounting base in a minute or so for inspection or repairs, or a spare set can quickly be substituted if desired.

Between the directional range beacons, the airways are dotted with brilliant lights which, several times a minute, alternate a flash of white with red flashes to identify their positions. These visual signals, like buoys along a water route, guide the pilot while he can see them. Yet, even when the weather is too thick to see the lights, the pilot knows his position from the directional signals which tell him what range beacon he is near—an important matter for the mail-plane pilots who fly in weather that keeps the passenger planes at the airport. Important, too, for a transport pilot caught in a sudden fog or squall.

But changes in weather conditions must be sudden indeed, to catch a transport pilot unaware. Before ever he leaves the airport at the start of a run, he examines last-minute weather reports from trained observers at points all along his route. Out of the teletype they come, clicking off on the tape the time, the point of origin and then a detailed systematic report, in standardized terms, of weather and wind, visibility and height of "ceiling" (as aviators call the lower side of the clouds). It is precise, exact, and conveys to the departing flyer full information as to present weather conditions all along his route. If he thinks them too unfavorable, he delays his start.

As these reports come in, the tape is cut off and pasted on a bulletin board, giving a complete picture of weather conditions. The picture changes as fast as the weather changes. Recently a further step has been taken: weather maps can be kept up-to-the-minute by teletypewriter. For this purpose, a machine is used that types with special characters on a page instead of a tape. A weather map is inserted in the sending and receiving instruments and a typist puts on it the symbols that indicate weather conditions at the points on the map on which he types them. They are reproduced exactly at all receiving stations on the circuit. A clerk draws in by hand the lines connecting points of equal barometric pressure, technically known as isobars. Such maps, transmitted at three-hour intervals in sections and pasted together, present a graphic picture of the information verbally typed on the tape. Both come over the wires—leased circuits provided by the Bell System.

Over leased circuits, too, the teletype clicks its reports of the arrival and departure of planes, of the number of passengers and the amount of mail and express matter carried, of arrangements to be made. Every message can be sent simultaneously to all or any of the teletypewriter stations on the circuit. In addition, the nation-wide telephone network of the Bell System is used extensively in connection with air transport service. Emergency calls there are, also, though happily they are few. Last but not least, the pilot's periodical reports of his position are sent by teletype to stations further along his route, and they are warned to watch for and report him as he passes overhead. Isolated? Cut off from the world? Not a bit of it. The transport pilot is constantly in touch with the far-flung ground force whose mission it is to keep flying safe.

System, team-work, intelligent foresight and information as to weather conditions at the moment all along the line—these are the factors that safeguard air transport today. According to the Federal Radio Commission, there were, on January 1st, 1933, 231 ground radio stations devoted entirely to aviation. These include stations used as radio beacons or for two-way telephone service. Transport passenger planes in daily communication with the ground stations numbered over 300; and there were also a number of private planes equipped for such communication.

How rapidly this system of radio telephone communication for airplanes has grown is indicated by the amount of such equipment which has been furnished by the Western Electric Company in the first three and a half years that it has been on the market. In 1929, 8 plane systems were furnished. In 1930 the air lines were supplied with 66 ground station systems and 52 plane installations. Twenty-nine more ground station systems were bought in 1931; and 117 additional planes were fitted with radio equipment. In 1932 the Western Electric Company supplied 20 ground station systems and 91 additional plane systems. In the aggregate, Western Electric radio equipment has been furnished for 115 ground stations and 268 planes in three and a half years. Not all of it is in continuous use, of course. Some is kept in reserve as spare plant by the air transport companies.

In the early days of aviation, newspaper writers used to refer to aviators as "birdmen." When we watch the great flocks of migratory birds fly to their Southern feeding grounds in the fall of the year and see them winging their way North again in the spring, we cannot but marvel at the instinct that guides their flight over hundreds or thousands of miles of land and sea. But when we see a great transport plane roaring through the sky at a hundred and twenty miles an hour, we know that not instinct alone but radio—not the least among many factors which contribute to safe flying—helps to guide and guard the pilot and his passengers every minute of their journey. If we are at all familiar with the history of electrical communication, we realize that the communication equipments which contribute much to the safety of air travel are developments that have been built upon the basis of Alexander Graham Bell's invention of the telephone. And these equipments are largely supplied by the organization that has developed Bell's invention into the nationwide telephone system that bears his name.

Richard Storrs Coe
Sterling Patterson

The Telephone's Place in Co-operative Advertising

"What," asked the professor, "is the American industry which is most widely advertised?"

"The motor industry," replied one member of his economics class.

"No."

"Tobacco," said another confidently.

"No."

"Foods," a third guessed hopefully.

"Not at all."

"Electrical devices," a fourth suggested feebly.

"All wrong," said the professor, with the assurance of foreknowledge. "The most widely advertised industry in America is none of these. It is the telephone business. We have learned that we must look for three elements before we can determine that a commercial enterprise is readily susceptible to advertising. The first of these is a constant demand for the product. The second is a sales unit that is small in size. The third is some inherent power in the product itself to stimulate the habit of its use.

"In the telephone business we find all three elements very much in evidence. The demand is as constant as the human desire for communication. The sales unit is the telephone call—obviously small. And the telephone meets so universal a need that the habit of its use can be readily instilled and fostered by suggestion.

"Any business combining these elements might be expected to rank among our large advertisers. But in this case there is a fourth element that transcends the others while embracing them. I refer to the intimate relationship that the telephone bears to the advertising done by other enterprises in every field of commercial activity. A vast army of merchandisers, selling everything from soap to automobiles, finds it advisable to suggest to its readers that the telephone be used in responding to its advertising.

"This practice of doing business by telephone I like to call 'telephone-merchandising.' And for those who are engaged in it I can think of no better term than 'telephone-merchants.'

"By means of telephone-merchandising the American people are daily, hourly, momentarily faced with the slogan, variously expressed, 'Use the telephone!' In the columns of the press, on the pages of the magazines, over the radio, by bill-board, direct-mail and word-of-mouth, thousands of telephone-merchants close their advertising messages with the reminder—'Our telephone number is thus and so—Call us.'

"And do the American people respond? They seem to. Twenty-five billion telephone calls are made by them in a year. That means a greater use than is made of all other forms of personal communication combined. For the number of first class letters is fifteen billion and the number of telegrams is less than a quarter of a billion.

"Now I have found you to be very practical-minded young men, and I can anticipate the question 'How many of these twenty-five billion telephone calls are the direct or indirect result of all this advertising?' Your guess is as good as mine. You may have the courage, but I doubt if you have the patience, to attempt such an estimate. But whether you guess at it or make a scientific study of it, you can start with the evidence of your common sense. It tells you very plainly that if all the telephone calls that are the result of present or past advertising were suddenly to disappear, not only would the telephone business suffer but our entire business mechanism would be thrown out of gear."

The Scope of Telephone-Merchandising

The Associated Companies of the Bell System have recently been giving much thought to what the professor calls "telephone-merchandising." Some have gone so far as to attempt such studies as he refers to. They have found that the volume of advertising being done by the telephone-merchants is so vast as to defy accurate measurement. From a series of test surveys, however, it is clear that not less than one-third of the local display advertising in the newspaper columns makes some reference to the telephone, if it be nothing more than to list the advertiser's telephone number. Of these advertisements about 10 per cent make a direct appeal to the reader to respond by telephone. A considerable number—telephone-merchants of the first water—build their advertising appeal around the advertiser's accessibility to the reader made possible by the fact that both have telephone facilities.

These surveys indicate the tremendous field which exists for aggressive telephone-merchandising. This great volume of telephone advertising is not half what it might be if the advertisers who are not telephone-minded could be made so and those who are already telephone-minded could be made more so.

Projecting the findings for the cities studied on a nation-wide basis, we may infer that telephone-merchants are paying not less than a quarter of a billion dollars a year for local newspaper display advertising that includes a telephone appeal. Projecting the findings still farther into the wide realm of advertising is something the author would rather leave to someone more statistically-minded.

The Merchandising Mind

Appreciation of the potentialities of the telephone in merchandising has contributed to the steady growth of the merchandising mind throughout the telephone industry during the past three years. With the recent temporary decline in the public use of telephone service, the industry is becoming more than ever an aggregation of people who, in thought and in act, are merchants of telephone service whether they be engineers, accountants, lawyers or physicists.

It is recognized that our experience during the depression differs from that of other commercial organizations only in degree. To the extent that these other organizations find themselves affected by curtailment of demand, we may reasonably assume that they have also been developing the merchandising mind. This assumption appears to be supported by a casual examination of the advertising that Business America is doing at the present time. And there can be no better reflector of the mind of a business than its sales messages to its customers. Two characteristics seem to mark America's advertising of 1933, distinguishing it from that of 1928.

First, 1933 advertising seems to be more emphatic. More direct. More suggestive of a longing to sell. It seems to be a message from men more filled with a desire to show their prospective customers how the product is fitted to the public need. It seems to be written with an eye more on how the public wants to read it and less on how the advertiser wants to say it. In short, 1933 shows us advertising in a buyer's market.

The second characteristic of America's 1933 advertising is one that concerns the telephone business even more closely. Recent years have seen a marked trend toward co-operative advertising. Large industries having a common message for the public, or whose products are allied in the public use, are joining forces. We have seen for many years how such groups as fruit growers and paint manufacturers can pool their national advertising resources. But it has taken the dark days to make a gasoline company so farsighted as to base an advertising campaign on the slogan " Buy a new car."

Now it was just as true in 1928 that a man would not buy gasoline until he had first bought an automobile. But there is something about the year 1933 that makes the truth more clear to all of us. It is as though there had been an awakening realization that we are all in the same boat; that nothing is to be gained by pulling against one another; that much may be attained by a concerted effort to row together.

In this trend toward co-operative advertising, it would be strange indeed if the telephone did not have a part, remembering the place it holds in advertising as reflected in the great volume of telephone-merchandising. As a matter of fact, two of the best examples of co-operation in the national field are the current Trade Mark Service and Long Distance campaigns of the American Telephone and Telegraph Company. Both, in their present co-operative form, were born during the dark days. They illustrate the 1933 trend. But more than that they illustrate how true it is that telephone advertising is as wide as advertising itself.

Trade Mark Service Advertising

The purpose of this campaign is to sell Trade Mark listings in classified telephone directories and thus to stimulate the use of the telephone in retail shopping. The appeal is to the national manufacturer. He spends thousands, perhaps millions, of dollars in nation-wide advertising. His return on this investment is in direct proportion to his ability to direct his readers to the dealers who carry his product. He can do this by listing these dealers under his trade name in the hundreds of classified directories that cover America, and by referring the readers of his advertising to these directories.

Thus do these manufacturers find that they can best advertise their wares by advertising the telephone too. A. T. & T. likewise finds that the best way to promote this Trade Mark Service, both with the manufacturers and with telephone users, is to feature in its advertising those who are already using it.

The photographed finger pointing to a Yellow Page listing of Kelvinator, Enna Jettick, Buick, Mimeograph and other nationally known advertising names is becoming familiar to the readers of America's magazines through A. T. & T. advertising campaigns. Equally familiar becomes the message of the manufacturers: " Find your local dealer in the classified telephone directory."

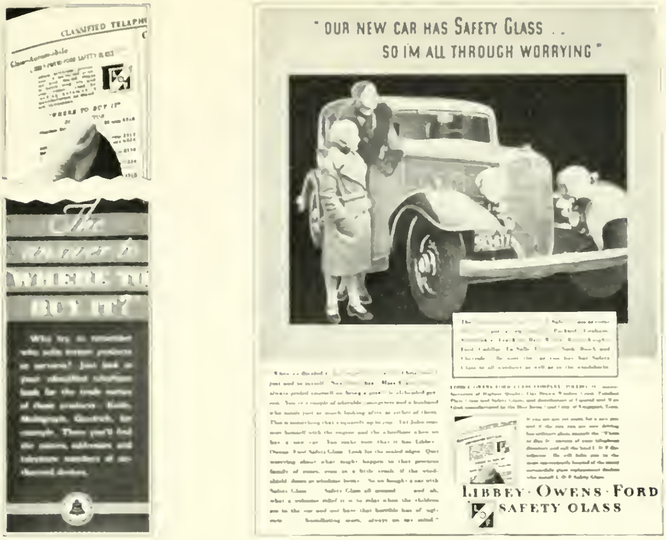
LONG DISTANCE "CASE ADVERTISING"

The purpose of this campaign is to promote the use of long distance telephone service by business organizations. It features specific instances in which telephone use has resulted in high sales at low cost, increased efficiency in administration, better service to customers, and decreased operating expenses. Not only is this campaign carried regularly in the national magazines, but Bell System newspaper advertising, which is under the direction of the Associated Companies in the field, has to some extent followed the same method.

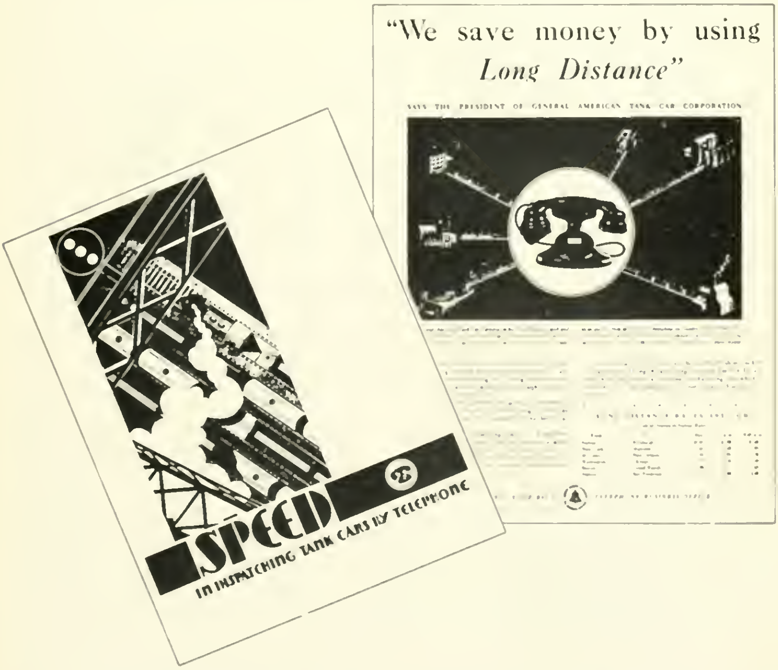
The readers of telephone advertising have thus had placed before them advertisements which say just as much about the business of the Norge Corporation, the Hazel-Atlas Glass Company, the Proctor & Gamble Company, and scores of others, as they do about the telephone company and its service.

These companies in turn frequently apply these same advertising messages to their own use in carrying their own story to their customers. Sometimes they ask the telephone advertising people to prepare copy for them. Sometimes they distribute to their own customers folders adapted from telephone advertising—in fact hundreds of thousands of such folders were mailed in this way during 1932.

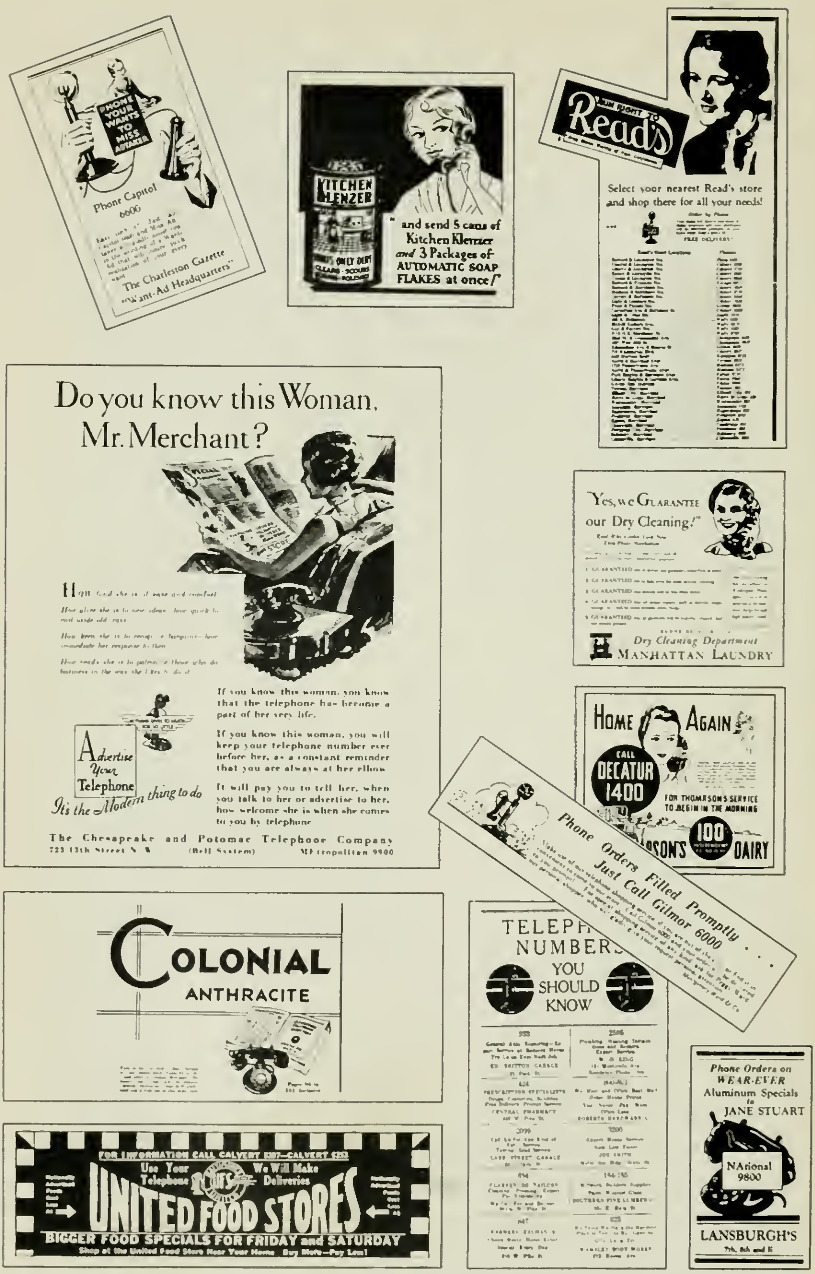
Thus when A. T. & T. mentions in its advertising the dispatching speed made possible to the General American Tank Car Corporation because of the telephone, this advertising message does not end there. The company thus advertised distributes to its own customers copies of the folder based on


CLASSIFIED TELEPH
"WHERE TO BUY IT"
"OUR NEW CAR HAS SAFETY GLASS . .
SO I'M ALL THROUGH WORRYING"
LIBBEY·OWENS·FORD
SAFETY GLASS

Magazine Advertisements which Illustrate How A. T. and T. Co-operates with National Manufacturers in Promoting Trade Mark Service.


"We save money by using
Long Distance"
SAYS THE PRESIDENT OF GENERAL AMERICAN TANK CAR CORPORATION
SPEED
IN DISPATCHING TANK CARS BY TELEPHONE

Booklet of General American Tank Car Corporation and Magazine Advertisement of A. T. & T. Co-operatively Developed.



PHONE YOUR WANTS TO MISS ADTAKER

Phone Capitol 6606

The Charleston Gazette
"Want-Ad Headquarters"

KITCHEN KLENZER

CLEANS · SCOURS

"and send 5 cans of Kitchen Klenzer and 3 Packages of AUTOMATIC SOAP FLAKES at once!"

Read's

Select your nearest Read's store and shop there for all your needs!

FREE DELIVERY

Do you know this Woman, Mr. Merchant?

If you know this woman, you know that the telephone has become a part of her very life.

If you know this woman, you will keep your telephone number ever before her, as a constant reminder that you are always at her elbow.

It will pay you to tell her, when you talk to her or advertise to her, how welcome she is when she comes to you by telephone.

Advertise Your Telephone

It's the Modern thing to do

The Chesapeake and Potomac Telephone Company
723 13th Street N. W. (Bell System) METropolitan 9900

"Yes, we GUARANTEE our Dry Cleaning!"

Dry Cleaning Department
MANHATTAN LAUNDRY

HOME AGAIN

CALL DECATUR 1400

FOR THOMPSON'S SERVICE TO BEGIN IN THE MORNING

DAIRY

Phone Orders Filled Promptly . . .
Just Call Gilmor 6000

Montgomery Ward & Co.

COLONIAL
ANTHRACITE

TELEPHONE NUMBERS YOU SHOULD KNOW

CENTRAL PHARMACY

Phone Orders on
WEAR-EVER
Aluminum Specials
to
JANE STUART

NAtional 9800

LANSBURGH'S
7th, 8th and E

FOR INFORMATION CALL CALVERT

Use Your Telephone

We Will Make Deliveries

UNITED FOOD STORES

BIGGER FOOD SPECIALS FOR FRIDAY and SATURDAY

Shop at the United Food Store Near Your Home Buy More—Pay Less!

TELEPHONE NEWSPAPER ADVERTISING DIRECTED TO MERCHANTS, AND EXAMPLES OF MERCHANTS' NEWSPAPER ADVERTISING SHOWING HOW UNIVERSAL IS THE FIELD FOR SUCH AN EFFORT.

this appeal. At the same time, another folder based on the advertising message is mailed out by Bell System sales forces in quantities running from 50,000 to 100,000 copies a month. The Bell System's advertising message is thus carried through this one channel to high executives in the fields of oil refining, chemicals, milk products, sugar refining, produce, paints and varnishes, lime and cement.

Working through the users of its service, the Bell System can get more out of its Long Distance advertising expenditure than it possibly could get working alone. Commenting on this subject, the Long Lines Department of A. T. & T. has this to say:

> This type of advertising has apparently carried more weight in all lines of business than the non-specific copy previously used, and it has definitely been helpful in strengthening relations with customers.
>
> An important outgrowth of the policy has been the development of an advertising service for many Long Lines customers and the coverage of a wider telephone market made possible by it. This has been accompanied by a corresponding enlargement of facilities for merchandising the magazine advertising.

Better Advertising Dollars

These two campaigns indicate very clearly that the Bell System is turning its attention to the development of its own advertising program in such a way that it will have a stimulating effect on the very much greater volume of telephone advertising that lies beyond its direct control. Co-operative advertising is particularly valuable to the telephone companies because their expenditures for advertising are not large when measured by the task to be accomplished.

Indeed, the Bell System's advertising program seems small when one considers the wide range of the markets and the media that it covers. It seems still smaller when measured against the gross revenues of the Bell System. It is actually much less proportionately than is spent by most of the large corporations with which we are now joining in one way or another to get our combined advertising message into the public mind. The telephone advertising bill amounts to about one-half of one per cent of gross telephone revenues, while large corporations generally spend anywhere from 2 per cent to 20 per cent of their gross for this purpose.

Clearly then, the telephone advertising dollar carries a heavy load. There is no room for extravagance in administering it. It must be husbanded to the last penny, so that its full value may be brought to bear on the huge job of merchandising telephone service. Small wonder if Bell System advertising men look with pleasure on the trend toward programs that make possible the strengthening of their efforts by merging them with the efforts of allied advertisers for that greater productiveness that usually accompanies joint effort.

It is important to the telephone business to strengthen this bond of mutual helpfulness with these other businesses which are its allies. They are actually dealers in the service that we are furnishing and selling. The statisticians tell us that there are in the Bell System about 115,000 private branch exchanges through which originate or terminate about one-third of all Bell System calls. The welfare of telephone-merchants is our welfare. Their loss is ours. If they fail to distribute as many calls as the size and type of their business activity seems to indicate to us they might, it is a matter of great concern to us as merchandisers. If we were national manufacturers distributing a product much less salable than ours, we would not be satisfied until every available dealer was not only carrying our line but aggressively promoting it.

This principle was recently well expressed by the General Manager of one of the Bell System's operating areas. "It has long been our practice," said he, "to make exhaustive surveys of a customer's telephone needs so that his facilities may be adequate to the volume of calls that they will be called on to handle. To do this job properly, we have usually found it necessary to study the customer's business in some detail. Our practices in this direction were developed to their highest efficiency when the great problem was how to handle an ever-increasing demand for our service that often taxed our best efforts to meet it. Now that our main problems have to do with getting all the new business we can, our attitude toward this large customer must undergo a change. We must approach him even more solicitously than before. Again we must study his business as intimately as our time and his patience will permit. But now we have a new reason for doing so. We want to show him how the telephone can fit more completely into his merchandising program. If by the use of our facilities we can help this customer to do more business and do it more economically, our business will benefit too."

Applying this principle to advertising, we find it well exemplified in the A. T. & T. national advertising above described. In these campaigns we see advertising filling its proper place as a function of merchandising. That is where we may expect increasingly to find it in the telephone business, side by side with sales and market analysis.

Approaching the merchandising problem from the viewpoint of advertising, telephone people find themselves confronted with a number of situations that call for the keenest kind of merchandising skill. Two of these revolve around the department store and the retail grocer, each an important outlet for telephone business. A consideration of them will serve to illustrate how wide, how universal and how important to the expansion of the telephone business co-operative advertising in the local community can be.

The Department Store

Most important in the list of telephone-merchants are the large retail stores in our big cities. It is not uncommon for them to have twenty, thirty, or even more sales people in constant attendance to handle telephone orders and inquiries, besides making great use of the telephone for other purposes. The attitude of these dealers in telephone calls is an important factor in the volume of a telephone company's business.

How can we determine what that attitude is? The easiest way is to scan the leading evening newspaper in any city of reasonable size. If the reader wishes to try it, he will find the experiment interesting, and it will take not more than fifteen minutes of his time.

I have one such paper before me as I write. Let us scan it together.

The first department store ad appears on page 11. It makes no reference to the telephone, but displays the store's street address prominently.

The same is true of the second department store ad which appears on page 16.

Store No. 3 is advertised on page 28. In the top right hand corner is a forceful suggestion that the reader call the store's personal shopping service.

Store No. 4 is advertised on page 29. The telephone number appears in both top corners, with plenty of white space, and the statement twice repeated " Phone orders filled."

Page 30 is filled with the ad of Store No. 5, but no reference is made to the telephone.

In 18-point type across the bottom of page 33, Store No. 6 reminds its customers that " Phone orders are promptly filled," and the telephone number follows in the same type.

Store No. 7 on page 35 uses both street address and telephone number wherever its name appears.

On the following page the full page ad of Store No. 8 is quite devoid of either street address or telephone number.

The back page carries the ad of Store No. 9. It is obviously planned to appeal to the telephone shopper, and carries in large type the slogan " Call (telephone number) for phone orders—Direct phone to our shopping bureau."

Now the merchandising problems of these stores do not differ greatly. They have the same sort of market, the same kind of merchandise and charge much the same scale of prices. They operate in the same city, and if you had a blanket one square mile in size you could throw it over all of them at one time. Moreover, six homes out of ten in that city have telephones, and ten thousand times a year the prospective customers of these nine stores ask "Information" for their telephone numbers.

How then can we account for such varied treatment of the telephone in the advertising which is the main link between these stores and their customers? Why is it that some seem indifferent to their telephone market, some seem almost to avoid it deliberately, while others aggressively seek to promote it?

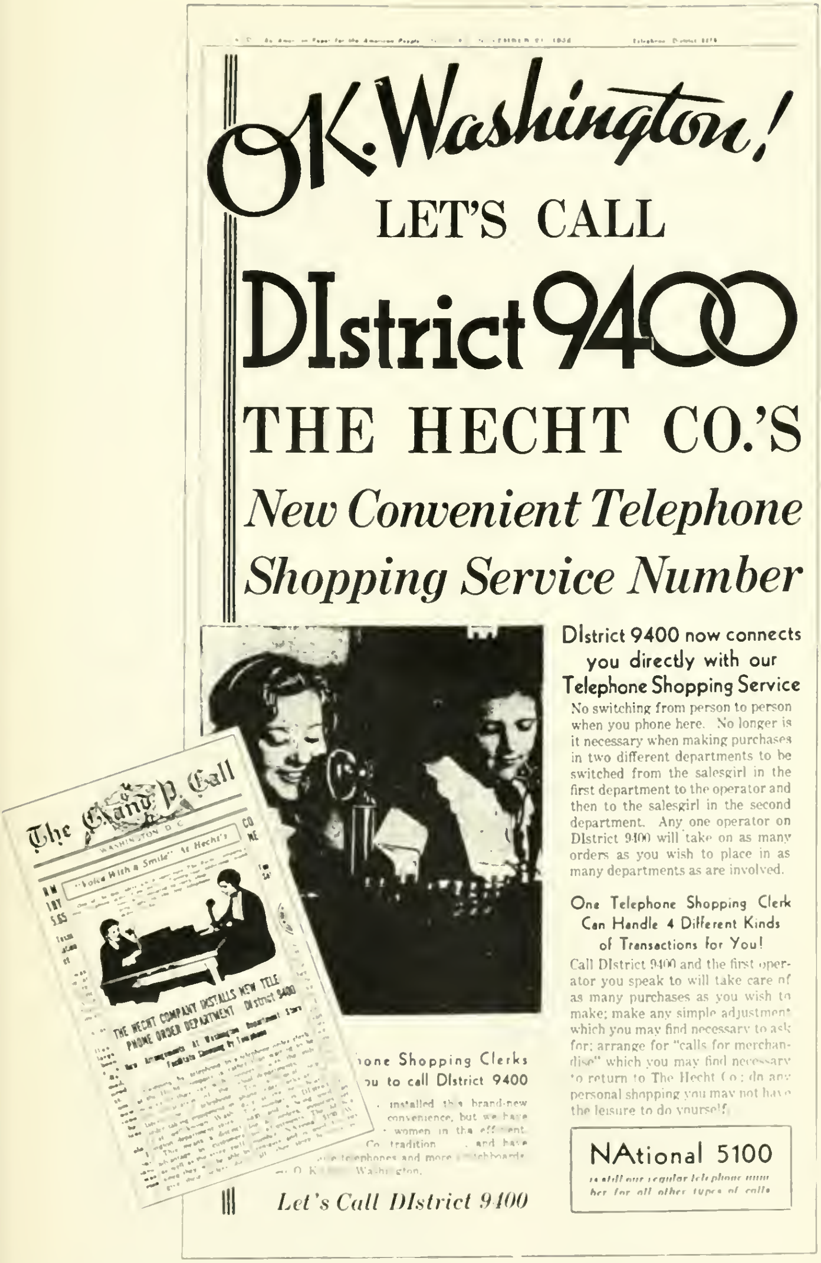
The answer probably lies in the fact that to the department store the telephone is but one side of a many-sided business. And also that many minds, with many merchandising points of view, are brought to bear on the advertising policies of each store. These points of view, like the opinions of all of us, are based partly on experience and partly on inhibition. The practices based upon them are bound to be as varied as they seem to be in my newspaper and in yours. They will continue to be so until such time as the ideas behind them are formulated into a universal acceptance of the true place and proper use of the telephone in modern merchandising. The furthering of this formulating process is the biggest advertising job now confronting local telephone companies.

In the city in which the newspaper we have scanned appears, the telephone company is attempting to aid the formulating process by telling the readers of this same newspaper why they should shop by telephone. But it does so in a still small voice as compared with the thunderous tones in which the stores themselves talk to the shoppers. How much better if it can so direct its advertising effort as to get the stores' volume behind its telephone shopping message! This is in fact the philosophy that is now guiding telephone advertising in that city. The telephone merchandising policy of Store No. 9 above is a direct outcome of a co-operative advertising plan between the company and the store. One week after the co-operative campaign was launched, additional facilities were being installed in the store to meet the increase in the volume of its telephone orders.

Most of us have a streak of laziness—or, if you will, a love of leisure. When we read an advertisement we may feel inclined to purchase the article described. But the physical effort of going to the store to get it, or even of looking up the store's telephone number, may be the difference between buying and not buying. The merchant whose telephone number is clearly displayed, and whose ad is prepared with the thought in mind that it will definitely win a telephone response, has a better chance of getting the order than the merchant who ignores the telephone entirely.

It seems obvious that, through its advertising and the efficient handling of the resulting telephone business, one large department store can do more to influence the shopping habits of the city's people than the telephone company can do directly. Multiply then that one store by all the other telephone-merchants whose advertising appears in that city's newspapers—particularly Stores Nos. 1, 2, 5 and 8—and it will be understood why the telephone company's own advertising is now being directed to the merchants as well as to the shoppers themselves. The appeal "Shop by Telephone" is being supplemented by copy that reads something like this:

> Do you know this woman, Mr. Merchant? How fond she is of ease and comfort. How alive she is to new ideas—how quick to cast aside old ways. How keen she is to recognize bargains—how immediate her response to them. How ready she is to patronize those who do business in the way she likes to do it.
>
> If you know this woman, you know that the telephone has become a part of her very life. If you know this woman, you will keep your telephone number ever before her, as a constant reminder that you are always at her elbow.
>
> It will pay you to tell her, when you talk to her or advertise to her, how welcome she is when she comes to you by telephone.



O.K. Washington!

LET'S CALL

DIstrict 9400

THE HECHT CO.'S

New Convenient Telephone Shopping Service Number

DIstrict 9400 now connects you directly with our Telephone Shopping Service

No switching from person to person when you phone here. No longer is it necessary when making purchases in two different departments to be switched from the salesgirl in the first department to the operator and then to the salesgirl in the second department. Any one operator on DIstrict 9400 will take on as many orders as you wish to place in as many departments as are involved.

One Telephone Shopping Clerk Can Handle 4 Different Kinds of Transactions for You!

Call DIstrict 9400 and the first operator you speak to will take care of as many purchases as you wish to make; make any simple adjustment which you may find necessary to ask for; arrange for "calls for merchandise" which you may find necessary to return to The Hecht Co.; do any personal shopping you may not have the leisure to do yourself.

hone Shopping Clerks
ou to call DIstrict 9400

installed the brand-new
convenience, but we have
women in the efficient
Co. tradition and have
telephones and more switchboards
O. K. Washington.

Let's Call DIstrict 9400

NAtional 5100

is still our regular telephone number for all other types of calls

The C and P Call

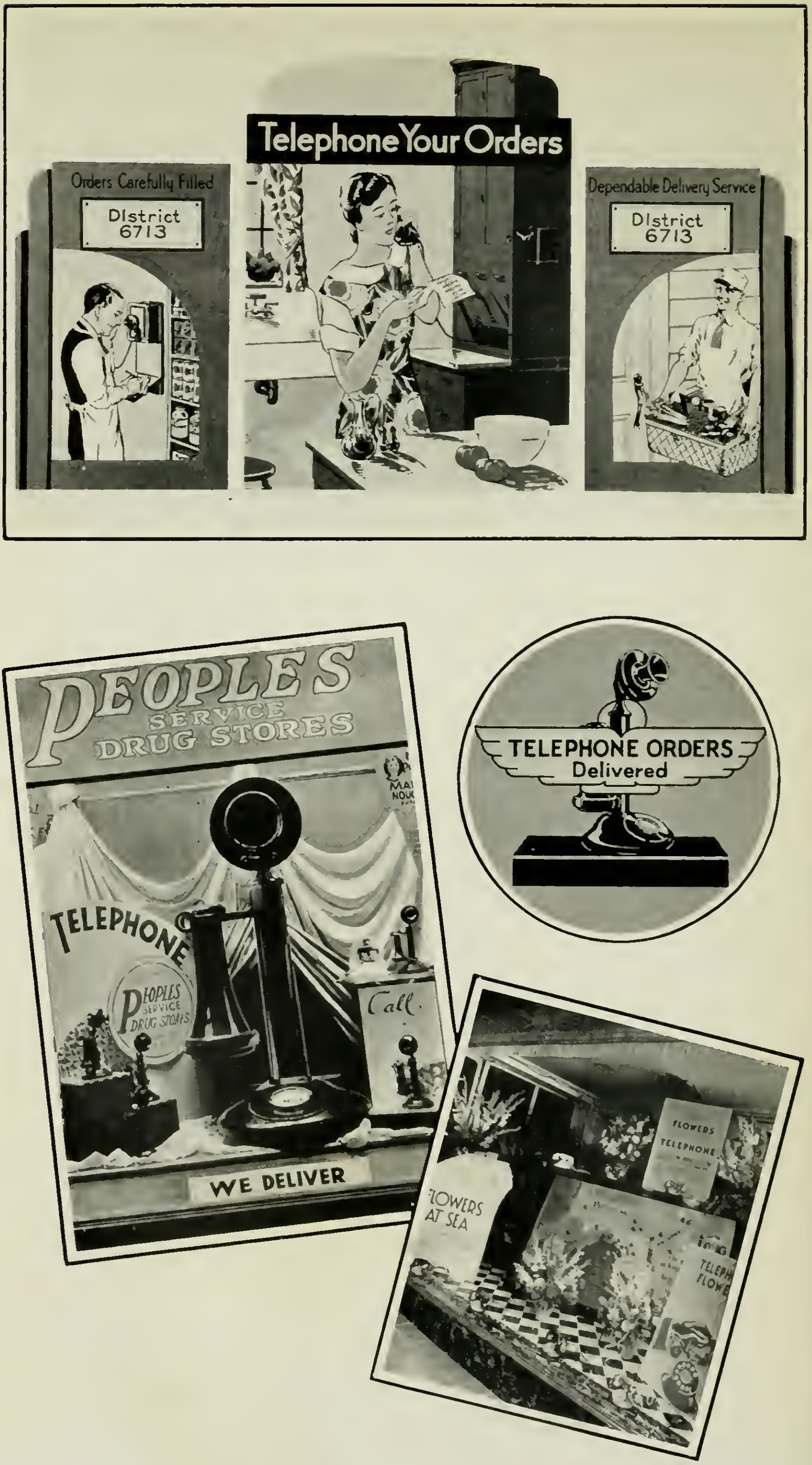
WASHINGTON D. C.

"Voice With a Smile" At Hecht's

THE HECHT COMPANY INSTALLS NEW TELEPHONE ORDER DEPARTMENT District 9400

New Arrangements At Washington Department Store Facilitate Shopping By Telephone

Department Store Newspaper Advertisement and Telephone Company's Bill Insert, Co-operatively Developed.



Examples of Window Displays Developed Co-operatively with Various Types of Small Retail Stores.

Co-operative advertising with department stores has expressed itself in various ways in Bell System Associated Companies. Telephone advertising departments have prepared copy for store advertising and display material for store windows. Standard telephone illustrations have been distributed to the stores. In one case a company carried the story of a store's new shopping facilities in its monthly bill insert. This insert, with its accompanying telephone advertising, the store in turn distributed in the packages of its customers.

These are merely straws that show how the wind is blowing. Co-operative telephone advertising can be widely developed to the joint benefit of department stores and telephone companies. To the stores it gives promise of sales that are now being lost. To the companies it makes possible an increased use of the telephone by both seller and buyer.

The Retail Grocer

Another group of telephone-merchants having great influence over the volume of telephone calls is the retail grocers. Their merchandising methods differ greatly from those of the department stores, yet in one respect they resemble them. Their telephone-merchandising has not kept pace with the growth of the telephone habit among their customers.

This is a serious obstacle in the way of telephone expansion. Chain grocery store groups have a sales volume of about three billion dollars a year. Assuming that the average grocery order is less than three dollars, this sales volume involves more than a billion individual transactions calling for communication between buyer and seller. Thus when we talk about the chain grocery stores we are talking about a market for telephone calls whose maximum possible development is not far from 4 per cent of all the telephone traffic now being handled in the United States. Now these grocer groups for the most part advocate "no-telephone-and-no-delivery" policies. The advertising man who is endeavoring to sell housewives the idea of "Shopping by Telephone" cannot be indifferent to a state of mind among the merchants themselves that works directly against the story his advertising tells.

A survey made in Baltimore a year ago developed the fact that 42 per cent of the housewives who have telephones would rather market by telephone than in person. From this it might seem that all, or practically all, grocery stores in that city do a substantial part of their business by telephone. But no. The fact is that out of 2,785 grocery stores in that same city, 804 have no telephones at all. And these are the larger stores for the most part, belonging to the chain groups.

The woman who markets in person goes through the same performance nearly every day, regardless of weather. She has to walk several blocks to the shopping section. Or she may back her thousand dollar automobile (costing ten cents a mile to operate) out of the garage and drive it to the store hoping to find a parking place nearby. She waits at the counter until a clerk is ready to serve her. Then she names the articles she wants and waits while the clerk assembles them one by one. In some stores she actually assembles them herself, cafeteria style. Most of these articles are so packaged or canned that she has no opportunity to examine the quality of her purchases. When a choice is desirable, the clerks quickly come to know her likes and dislikes. She returns home after consuming the best part of an hour in a task that could have been accomplished in five minutes by use of the telephone in her home.

What arguments have the non-telephoned grocers to present that induce the women of a large city to go through this rigorous task every day, *and like it?* The chief argument is that by saving the cost of a telephone-and-delivery system, they are able to shave the prices of their goods. Expressed in terms of an individual order, this cost could hardly be more than 5c. To save this amount the shopper spends the best part of an hour. It would be absurd to say that any grocer appraises the time of any housewife at 5c an hour—a mere fraction of that paid regularly to common labor. Certainly the housewife would agree to no such appraisal. The truth probably is that neither the housewife nor the grocer has thought about the matter in this light.

The telephone business has too much at stake to be indifferent to a state of mind which does not appreciate the uses and advantages of the service it is selling. With increased thought given to their merchandising problem, we may reasonably expect to find telephone companies taking steps to change it. The first step would seem to be to sell the idea of telephone service to the grocers, adapting it as may be necessary to meet the grocers' needs. The second step would then be to join with the grocers, through co-operative advertising, to bring the desirability of telephone marketing to the attention of the grocers' customers. With at least two-thirds of the grocers, in most cities, already more than half convinced, this task does not seem to be an impossible one.

If a large wholesale grocer should find an increasing number of storekeepers indifferent to his line, his procedure would be simple enough. He would attempt to adjust his product to meet the wishes of these indifferent grocers. At the same time he would redouble his efforts to create a public demand for his product by helping the friendly stores to distribute it more widely.

There may be a parallel here for the telephone business. In Baltimore the telephone company has undertaken an experimental campaign in co-operation with telephone-merchandising grocers which indicated that there is. In the neighboring city of Washington, a co-operative advertising plan that cost the telephone company $600 was instrumental in chain store installations now bringing in revenue of $19,000 a year, besides making possible a step in the direction of fitting the telephone to the joint needs of the chains and their customers—a consummation devoutly to be wished.

These cities are mentioned here because they have come within the writer's direct observation. Similar examples can undoubtedly be found in other cities, for the urge toward co-operative advertising to stimulate telephone business is not restricted to any particular area or company.

Conclusion

Important as telephone-merchandising is because of its effect on the telephone advertising program, it has a much broader significance than that.

A vitally important contribution that our generation should make to civilization is the development of a system of distribution that will make it possible for the people of the world to consume the output of their highly developed production system.

Advertising is the best means known to our generation to get this output before the wide-flung markets of the nation.

The telephone is the best means known to our generation whereby the buyer can quickly respond to the advertising message.

Advertising and the telephone can thus contribute materially to the solution of an important economic problem. In this fact there is a challenge—almost it amounts to an obligation—for these two forces to work together.

J. M. Shaw

Myths of Telephone History

EDITOR'S NOTE:

There have been as the years passed many stories told and repeated about the invention and development of the telephone which are not true. Some are entirely imaginative. They are still frequently referred to the librarian of the American Telephone Historical Collection for verification. His primary interest has been in reporting what the records show, but he has naturally also been interested in noting how far these stories have traveled away from the facts, and how it was that they have reached their present form and character. This article embodies what he has found,—in the various records, written and printed, documentary and legal,—in the historical library of the American Telephone and Telegraph Company to account for some of these myths.

HUMAN nature is idealistic. But much that is idealistic is not therefore ideal. Mankind is often chary of the facts, content to get along with a few of them instead of anxious for all of them. Even, or especially, in the immutable realm of the past, we are prone to feel that what we think ought to have been, was so. This is essentially the trouble with much written history. An imaginative statement once invented and promulgated, the present purposes and immediate interests of active life and business bring their pressure to bear in its favor. In this way are many myths born. For the rest, we glide care-free back through the past, seeing things indiscriminately, some of which like the Ichthyosaurus have come and gone through evolution, and some of more purely mythical character have come and stayed.

Among the best authenticated instances of telephone myths stands the pathetic figure of Joshua Coppersmith. Joshua had a clever father, whoever he was. The son is plausible in form, and he still wanders up and down the land, doing odd jobs filling space in worthy periodicals. Like other famous characters, his birthplace is variously credited,—to New York, to Boston, to "somewhere in the East." There is reason, it may be stated, to add to the list an enterprising town in the Middle West. Naturally no one of his editorial sponsors has thus far been able to cite for verification the name of the newspaper and the date on which the news of Joshua Coppersmith was first printed, but this it may be unreasonable to ask.

Whenever it was, the story goes that:

> A man about 46 years of age, giving the name of Joshua Coppersmith, has been arrested in New York for attempting to extort funds from ignorant and superstitious people by exhibiting a device which he says will convey the human voice any distance over metallic wires so that it will be heard by a listener at the other end. He calls the instrument a 'telephone' which is obviously intended to imitate the word 'telegraph' and win the confidence of those who know of the success of the latter instrument without understanding the principles upon which it is based. Well informed people know that it is impossible to transmit the human voice over wires as may be done with the dots and dashes and signals of the Morse Code, and that, were it possible to do so, the thing would be of no practical benefit.
>
> The authorities who apprehended this criminal are to be congratulated, and it is to be hoped that his punishment will be prompt and fitting that it may serve as an example to a horde of other conscienceless schemers who enrich themselves at the expense of their fellow creatures.

There are a number of little slips in this story to arouse suspicion. The offense charged is extortion, rather than swindling. But the man is said to have exhibited the device. Why then would not a simple demonstration have either confirmed the charge or justified the defendant? But the appeal is rather to the indefinite "well-informed." On analysis, as often proves to be the case, the real implication is against the Press and the Courts, the one for apprehending and the other for demanding long imprisonment on a charge that any way you take it will not hold water. But alas, newspapers and periodicals still amuse themselves by harrassing the poor man, now long past a hundred years old, although there never was any such man. In all fairness and kindness old Joshua's ghost should be allowed to rest in peace.

Myths naturally grow in profusion around the hero. So has it always been; and so is it likewise in the case of the telephone.

One of the major myths of Alexander Graham Bell, and curiously one of the most popular, is that on more than one occasion he offered to sell telephone stock for ridiculously low prices, for $10 a share and even $1.00. One story declared that he offered a share of stock for a meal, because he was so poor. How rich this person's own father or grandfather would have been if he had only loosened up and accepted the offer, was a matter for simple computation. These tales all reflect of course on the acumen of those who refused the golden opportunity, but nonetheless these dreams of the might-have-been seem to be favorites with their sons and grandsons.

Now, what are the facts? Alexander Graham Bell was in no way interested, nor was he at all active in the business side of the development of the telephone. He was absorbed in the scientific side of the invention and in its human possibilities, what it could do for mankind,—for men and women and children in their daily lives. He never peddled stock; nothing could have induced him to do it. Nor was there any need for him to undertake it. In the hands of the wise Gardiner Greene Hubbard and the experienced Thomas Sanders, with Theodore N. Vail added in the summer of 1878, there was no need for Mr. Bell to try anything of the kind. He never sold a single share of stock for the company. As to his selling his own personal stock, he had only 10 shares in his own name in the early days. All the rest of his 30 per cent of the stock he gave to his bride as a wedding present.

The flower of the telephone stock myths is the one relating that at the Centennial Exhibition in Philadelphia in 1876 anyone could talk through the telephone for 25 cents and buy a share of stock for 4 cents. But there was no telephone stock at all at that time; not until August 1, 1877.

It would seem that there must have been some basis for these stories. How did they start? Those who relate them are mostly people of honesty and intelligence, entirely sincere. It may be there were some instances in which the stock was that issued by one of the local agents who were organizing telephone exchanges under licenses from the Bell Company. More likely it may have been the stock of one of the acoustic telephone companies, that put out the "lovers' telegraphs," the two-tin-cans-and-a-string playthings. Some of these instruments were quite practical for short distances. But the stock was not that of the Bell Telephone Company, or of either of its successors, the National Bell or the American Bell Telephone Company. The two men who certainly knew,—Thomas Sanders, the treasurer, and Charles Eustis Hubbard, the secretary,—both of them wrote signed statements that telephone stock was never sold for less than $50 a share; and those statements are now in the American Telephone Historical Collection. Telephone stock sold on the market for the first time in the summer of 1879,—for $110; and following the settlement of the so-called Western Union Case, it sold in December, 1879, for $995. In that whole price range no one was very scornful! Since then the prices of telephone stock have been a matter of record. So the whole history of telephone stock is covered from the date of the first issue to the present. It is easy after forty or fifty years for the memory to slip in the matter of dates by a year or two. Still more is it easy, indeed natural, if there be involved a distinction between different companies, or between two radically different kinds of apparatus, such as between the acoustic telephone which operated merely by physical impulse, and now long since forgotten, and Alexander Graham Bell's telephone, which transmitted speech by means of electricity.

There have been two contradictory myths directly connected with the inventor of the telephone. They were closely related to each other; it may be the one sprang out of the other. The one avers that Bell's invention of the telephone was an offshoot of his work for the deaf, indeed that he invented the telephone to enable the deaf, especially his wife, to hear and to speak. Alexander Graham Bell was deeply interested in the education and the welfare of the deaf all his life; it was his chief interest and was central among all his many varied interests. As for the sentimental motive, there never was any occasion for him to invent anything of the kind for Mrs. Bell's benefit. She spoke very intelligibly and could read the lips of anyone with whom she was conversing readily before Mr. Bell ever met her, and she never was really in the proper sense of the term his pupil.

There is an essential distinction that many people ignore between those who are hard of hearing, even very hard of hearing, and those who are really deaf. Mrs. Bell was deaf, had become so through scarlet fever when a little child. So too Mr. Bell's five-year old pupil, George T. Sanders, was absolutely deaf, born deaf. The telephone could not possibly help either of them. The development of amplification and selectivity which have been accomplished by the Bell Telephone Laboratories in the Audiphone during the last ten years will greatly help those who are hard of hearing, but the telephone can do nothing for those who have no auditory nerve. Except that Bell in pursuing each of his varied lines of research always kept his mind alert for anything that might apply to any one of his other lines of work, Bell's work for the deaf did not lead to his invention of the telephone. Indeed, Bell got started in his work for the electrical transmission of speech several years before he became interested in the deaf.

The other myth connected with his work for the deaf is that

Alexander Graham Bell very soon turned against the telephone and would not even have one in his house. A tragically romantic eventuality! One of the gargoyle incidents of the history of science and of civilization! Alas for the sternness of truth that checks the throbbing tear! He discontinued his work on the telephone because he believed he had completed his part in the development and that others could do what had now to be done, whether technical or commercial, as well as he could or better. Also, and even more, as has been said, his chief interest was in his work for the deaf. He wanted to get back to that great human work. No, there was nothing morbid or abnormal about his attitude toward the telephone. He appreciated it, and heartily honored those who carried on his work, saying years later that he could hardly believe that he had ever had anything to do with this wonderful means of nation-wide communication.

There is in the American Telephone Historical Collection a contract dated April 1, 1881, and renewed in 1886, between Alexander Graham Bell and George C. Maynard, agent of the American Bell Telephone Company, calling for telephone lines between Dr. Bell's residence, his laboratory and the homes of his family and of relatives, with an additional telephone line to his laboratory, eight lines in all! And during the latter part of his life Dr. Bell had a telephone in every room of his house except his private study and the parlor. So, too, at his summer home on Prince Edward Island, he had a private telephone line six miles long going around the Bras d'Or Lake to Baddeck; he had three telephones in the house and a telephone in every building on the place,—even, for emergencies, at the little cabin deep in the woods where he used to go alone for uninterrupted thought. Far from turning against the telephone, no one could have shown a more practical appreciation of it than he, nor taken it more intimately into his daily life. The only fact that can have given rise to this myth is that

Dr. Bell did not want a telephone in his own private work room.

If anything under the sun be only big enough it is easy to subject it to attack. The Lilliputians appreciated this when they saw Mr. Gulliver and they forthwith proceeded to tie him up. Telephone history supplies for the convenience of mythology a similar giant, the telephone litigation of 1878–1893 et seq. Myths grow luxuriously in the rich soil of litigation. Any moderately attractive myth-germ can get started in it and have a fifty-fifty chance of coming through to wide acceptance, for as sure as one side wins, the other side loses. In the minds of the losers then it is incontrovertible that the decision was all wrong; that the court itself was, must have been, prejudiced (a suspicion never entertained until after the decision); and what could so clearly have been behind the wrong decision of a prejudiced court as—money? So the banner of the lost cause is raised over the battle ground and the soil is fertilized for any promising young myth that may hope to cut a figure in this cruel world. If perchance the court was conspicuously unanimous in its wrong decision, what proof could there be more positive of judicial subserviency to the will of the victorious litigant? And there you are.

Consider then the deplorable conditions in the telephone litigation, in which there was a tangled mass of no less than six hundred law suits, all of them decided in favor of Alexander Graham Bell as incontestably the actual and the first inventor of the telephone. So not a few vigorous little myths crawled from out the larva stage and the fostering care of interested parties and soon winged their way to the credulous belief of a sympathetic public.

Unfortunately a few hard facts are necessary to the full appreciation of this interesting phenomenon of the mythological lepidoptera and of the beauty of their flight. But these facts may be briefly presented. The six hundred lawsuits of the telephone litigation in regard to the validity of the Bell patents may be divided into two parts. The first consists of one single case, the so-called Western Union Case; the other part consists of the remaining 599 cases. That first case had real merit. It presented to the court a real issue for decision: Did Bell merely invent an instrument, as the Western Union Telegraph Company contended,—in which case the Western Union's inventors, Elisha Gray, Amos E. Dolbear and a young man by the name of Thomas A. Edison who had invented telephone instruments, had *not* infringed Bell's patents; or, as the Bell Telephone Company contended, did Bell not merely invent an instrument, but discover how to use electricity for the transmission of speech,—in which case Gray, Dolbear and Edison and the Western Union Telegraph Company *had* infringed the Bell patents? This case ended without a judicial decision by the admission of the counsel of the Western Union Telegraph Company that the Bell patents were valid, that the Bell contention was correct, and that the only thing for his clients to do was to settle. This was done. The agreement was signed on November 10, 1879, and the settlement was approved and confirmed by the court. It is obvious that no judicial decision could have settled the matter in a more positive way.

Soon it was evident that there was a future for the telephone. There speedily sprang up countless infringing companies whose activities may be characterized generally as selling as much stock as they could to the public before they were sued for infringement and stopped by injunction,—with, in some cases, the hope in reserve that they might win out and fall heir to a negotiable interest in part or all of the telephone industry and the emoluments thereof. The Bell Telephone Company and its successors of course had to sue all of these for infringement. There resulted, in the words of Mr. Justice Brewer of the United States Supreme Court, "the most important, the most protracted litigation that has arisen under the patent system of this country." The record of this litigation takes up 149 volumes. The defendants in these cases availed themselves of many varied expedients to complicate the progress through the courts, reintroducing depositions and witnesses from other cases and sometimes with slight changes resubmitting issues that had essentially already been decided. Few cases, if any, stood alone independent of other cases. Indeed, the litigation as a whole constituted an involved, inseparably tangled network. Yet in the end Alexander Graham Bell and the Telephone Company won the litigation as a whole and every single lawsuit in it.

This outline is enough to understand and enjoy the inception of two of the most far-reaching myths in the history of the telephone. The first of these sprang from the activities of an enterprising character, Dr. Seth R. Beckwith, a man so shrewd and so resourceful as to make him a truly fascinating figure. To say that he was consummately able is not however to say that he was strictly scrupulous, except in the masterly discrimination with which he pursued his own ends. Dr. Beckwith appreciated the possibilities of the telephone business; he appreciated that it was a big business and that it could be a bigger business. He appreciated that anyone who undertook to contend with the Bell Company must be ready for stiff litigation. He laid his plans accordingly. In February, 1883, he organized the Overland Telephone Company in New York and proceeded to organize under it eight other Overland Telephone Companies as the beginning of a network of Overland Companies covering the whole country. These were skillfully co-ordinated with each other for purposes of concerted action, and at the same time kept skillfully interseparated from each other for purposes of legal strategy. He retained for himself 7,200 out of 10,000 shares of the stock of the main company, and took the position of General Manager, so that he controlled the company in every point of policy and of operation. For his apparatus he secured the telephone patents of one Myron L. Baxter of Aurora, Illinois. The application for these patents was filed in December, 1882, and they were issued in May, 1883. It will be seen that Dr. Beckwith did not wait for the decision of the Patent Office on the merits of these patents; that was a secondary consideration. The Bell Company instituted proceedings against the Overland Company and the case promptly went to trial.

But Beckwith was not the man to neglect provision for future lines, either of retreat or of advance, as might be advisable. As the Overland case progressed during the summer and fall of 1883, Dr. Beckwith realized that his company might lose; he probably became convinced that it would lose. At any rate, on December 31, 1883, he quietly severed all connection with the Overland Company, whether as director, stockholder, or general manager. Accordingly when later the Bell Company won the suit and an injunction issued against the Overland Telephone Company, he had no longer any connection with the company, and no restraining order or injunction issued against the said Seth R. Beckwith. He had eluded the pursuit and was free to make another attack. We are now no longer interested in the fortunes or misfortunes of the Overland Telephone Company or of its attendant companies, no more than was Dr. Beckwith. Mythological possibilities followed the resourceful career of Dr. Beckwith. And so do we.

There was incorporated on April 2, 1883, in the State of New York, another telephone company, the Globe Telephone Company. There is nothing to show that Dr. Beckwith had anything to do with its organization, but it does not seem impossible that he instigated it as a reserve for use in case of need. It would be like him. Early in 1884, it began a tentative multiplication that suggested the plan of the Overland Company. Contrary to the practice in the Overland Company, however, the Globe Company remained singularly innocent of any commercial activity. A year later, the officers of the company certified that "$10,000,000 had been paid in, in the form of property necessary to the business, namely patents and patent rights, and stock had been issued therefor." These valuable patents seem to have been the telephone patents of one George E. Shaw, but it does not appear that either any practical or any legal use was ever made of them.

Nothing happened in the Globe Telephone Company for another year. They were careful not to do anything that might subject the company to injunction for infringement. In June, 1885, however Dr. Beckwith became interested in Antonio Meucci of Staten Island, and things began to happen. At the same time Beckwith began to use the office of the Globe Telephone Company in the Mills Building in New York. A continuity in events may be indicated by the fact that one of Beckwith's directors in the Overland Telephone Company, Erastus Wiman, lived on Staten Island; he may have found Meucci for him. In August, 1885, Beckwith became a stockholder (5,000 shares) in the Globe Telephone Company and its General Manager. He said later that his services were confined to securing testimony regarding Meucci's inventions and evidence of fraud in the obtaining of Bell's patents. The last week of October, provocation having been sufficient, the Bell Company sued the Globe Telephone Company for infringement.

Meucci fitted perfectly into Beckwith's plans. From the Overland case Beckwith had learned that reliance on any telephone patents of later date than Bell's,—such as Baxter's, or Shaw's,—was vain. A claim must be based on new evidence, alleging invention prior to Bell's. Meucci really had invented, years before, what could, in the loose phraseology of the time, be called a telephone. To be sure, it was an acoustic and not an electrical telephone. He had filed a caveat for it in the United States Patent Office in 1871 and later renewed it twice, but he was never granted a patent. For that matter, others had invented acoustic telephones before he did. Further, Meucci was an aged Italian, 77 years old, a Garibaldi veteran; he could speak English somewhat, but not readily. All these circumstances were handicaps to Meucci's interests in court, but they were distinct advantages for Beckwith's purposes. In brief, Antonio Meucci made a romantic figure and his claim properly handled might be the instrument for breaking the Bell Telephone patents.

Beckwith began the proper handling on the first day of the trial by pleading the age and foreign nationality of Meucci and of his chief witness, the 81-year old Domenico Mariani, and getting permission to have their testimony taken in the form of depositions, and thus minimizing their appearance in court. But the prospects in the Globe case proved to be no better than in the Overland case. So, about April 1, 1886, without interrupting the court proceedings, Beckwith withdrew entirely from the Globe Company, and while testimony was still being taken in that case, went over to Elizabeth, New Jersey and started another company, still using the claims of Antonio Meucci,—for which he offered the old man, but did not deliver, 100 of the 1,000 shares of stock, though retaining for himself 690 shares,—and boldly calling it the Meucci Telephone Company of New Jersey.

Naturally Meucci and his personal attorney, David Humphreys, did not like Beckwith's abandoning him in mid-trial, and when Beckwith was sued in New Jersey by the Bell Company and he proceeded to base his defense on Meucci's deposition, they objected strenuously, Humphreys accusing his former colleague and friend of "villainous misrepresentation" and so forth. But all that Beckwith could do was in vain. The Bell Company won the Globe case of course. While the Globe Company appealed to the United States Supreme Court, it never filed its briefs. Beckwith gave up his defense in the Meucci Telephone Company case in New Jersey. And that was the end.

But that was not the end of Meucci. Out of Beckwith's exploitation of him arose the myth of Antonio Meucci as the inventor of the telephone.

It was the most natural thing in the world under the circumstances that Antonio Meucci himself and his Italian friends, not understanding the technical differences involved nor following easily the court proceedings, should believe that he had been defrauded and that the Bell Company was to blame for this miscarriage of justice. The banner of the lost cause was raised and under it many loyal Italians here in America have rallied ever since. Such a belief would of course supply them with a simple solution of the whole matter, and blind them to the real issue in the case. Yet there is not and never has been any ground for this belief.

This issue was very simple. As has been said, what Meucci invented was an acoustic telephone. Acoustic telephones operate by direct physical impulse and work very well over a short distance. Meucci's did. Alexander Graham Bell, on the other hand, discovered how to use electricity in the transmission of speech. By physical impulse the voice travels through the air, as in ordinary talking, singing or yodeling, at a speed of about 1,100 feet a second; through a string or a metal wire, maybe a little faster. By electricity the voice goes at the rate of 185,000 miles a second. This was the basic element in Bell's invention which was in no way a development of the acoustic telephone. Meucci thought he was using electricity. But with all respect be it said, he was mistaken,—nor is it surprising that he should be. He was not a trained scientist; his various inventions were not the result of systematic scientific research, as were the inventions of Edison, Elisha Gray or of Bell. In his caveat, Meucci stated that his "system consists in isolating two persons by placing them on glass insulators, employing glass for example at the feet of the chair or bench on which each sits." Probably he thought this would keep the electricity in, prevent it from escaping. Nowadays of course everyone knows that the glass insulation would prevent there being any electric current at all. But Meucci's apparatus would work equally well with the insulation and without. Certainly; because it worked by physical and not by electrical impulse.

Myths are strange affairs. They are like clouds floating across the sky, none of them, even the highest, really very far from the ground. Like the myths in this article, they are quite different,—heavy or light,—some ephemeral and amusing, some grotesque, hardly to be taken seriously, some sinister. And they all speedily or slowly melt in the blue sky or pass on over the earth out of sight, are gone and forgotten. One more may be recounted here, the strangest of all, a dark cloud bearing tragic unhappiness in its piled-up masses and muttering with the distant echoes of a storm. It is the myth of Elisha Gray.

Elisha Gray was one of the prominent inventors of the latter half of the 19th century. He was thorough and systematic in his researches and experiments. His great invention was the multiple telegraph. While he was working on that, he gave some time and interest to the possibilities of transmitting speech by electricity. He succeeded in transmitting musical tones in that way. But that was a very simple matter compared with the transmission of the extremely complicated overtones of speech, which required an entirely different kind of electric current from the make-and-break current of telegraphy. Gray put his tentative ideas into form in February, 1876, and filed a caveat therefor in the United States Patent Office on February 14th.

But Alexander Graham Bell had invented his telephone nine months before, on June 2, 1875, and he then had a patentable article. In order to have his invention patented at the same time in England and in America he delayed filing his application until February 14, 1876, when he filed it, as it happened, a few hours earlier than Gray filed his caveat. The technical difference between the two is important. A caveat serves notice with the Patent Office that the inventor expects to invent something, whereas an application asserts that the invention has already been completed. Therefore on February 14, 1876, Elisha Gray filed notice that he expected to invent a telephone, whereas Alexander Graham Bell filed notice that he had invented a telephone. In subsequent litigation the question of Elisha Gray's claim that he preceded Bell in the invention was adjudicated and decided in Bell's favor.

But the closeness of the times of filing became exaggerated in the minds of some people into real importance, and this was further exaggerated by the intense feeling of the ensuing litigation. Even Elisha Gray, as time passed, fell into this error himself. But not at first. Both Bell and Gray exhibited inventions at the Centennial Exhibition at Philadelphia that summer of 1876. On Sunday afternoon, June 25th, Bell demonstrated his telephone before the Judges of Electrical Instruments and Instruments of Precision. Elisha Gray himself was present. Among the judges were Sir William Thomson, later Lord Kelvin, and Prof. James C. Watson of the University of Michigan. In the scientific periodical, *Nature,* for December 5, 1878, Professor Watson told about certain experiments that he and Sir William made with Bell's telephone after Bell had returned to Boston and about Elisha Gray's comments on them.

> The news of these successful experiments soon circulated freely, and the day following, or possibly two days afterwards, Mr. Gray came to me and inquired whether the reports of our success with Bell's telephone were correct; and upon receiving from me an affirmative reply, he said that it was impossible, that we had been deceived in some way, that the transmission was by actual metallic contact through the wire, and that it was, to use his own words, "nothing more than the old lover's telegraph." In reply I said to him that we had taken every possible precaution against error, that we were both convinced of the reality of Bell's claims, and that Sir William Thomson would report to that effect. He persisted in his statement that the result was impossible, and that we must have been deceived in some way or other.

If Professor Gray was so sure that Bell's invention could be nothing more than another acoustic telephone, like Meucci's, and that an electric telephone was impossible, he could not have regarded his own caveat as asserting more than a chance that he might solve the problem, much less that he had already actually invented it himself.

However Professor Watson's statement is not the only evidence of this. Some friction arose between Bell and Gray on account of certain statements that Professor Gray made in a lecture in Chicago, and that seem to have been incorrectly reported in the press. In a letter that Elisha Gray wrote with his own hand to Alexander Graham Bell on March 5, 1877, he said of his lecture: "I gave you full credit for the talking feature of the telephone. . . . I described your apparatus at length by diagram." And again farther on in the same letter,—"I do not however claim even the credit of inventing it, as I do not believe a mere description of an idea that has never been *reduced* to *practice*—in the *strict sense* of that phrase—should be dignified with the name invention." (Italics Gray's.)

How could it be then, in view of these plain statements of his own, that Gray ever actually and (paradoxical though it be) sincerely believed that he antedated Bell in the invention of the telephone? He was not deceived, as Meucci was, by any one. He was competent to reach the truth of the matter from his own knowledge of electricity. It came about through an unaccountable habit of human nature. The strange fact was described in a sentence by Judge Sprague in Howe *vs.* Underwood: "After having seen what has been done, the mind is very apt to blend the subsequent information with prior recollections and confuse them together."

Beside this tendency common to most people, Gray was considerably older than Bell. He was of very serious nature; there was no lightness in his nature that would enable him to throw off disappointment and take defeat easily. It hurt his pride that the young teacher should have invented what he had started to work on and which he had regarded as impossible. Then the floods of legal contention swept deliberation and calm judgment away in the swirling currents of the litigation. That he invented the telephone became *une idée fixe.* He brooded over the disappointments of the struggle and became an embittered man. When he died, there was found among his effects, a scrap of paper in his own writing on which was written:

> The history of the telephone will never be fully written; it is partly hidden away in 20 or 30 thousand pages of testimony and partly lying on the heart's and consciences of a few whose lips are sealed—some in death, and others by a golden clasp whose grip is even tighter.

From this it will be seen how cruelly sincere he was in the belief that it was he who invented the telephone. It is sad, tragic. And it is regretted especially in the Bell System, for Elisha Gray was one of the founders of the Western Electric Company and is honored, now that the bias of those days has passed away, for his own great merits. His empty claim has become a myth. His adherents in the days of the telephone litigation, and his friends, perpetuated his claim and rallied devotedly to him under the banner of the lost cause. But time is healing the wounds, and allaying the bitterness of former days. The Elisha Gray Collection in the Historical Library of the American Telephone and Telegraph Company preserves many of his papers and impartially welcomes any material pertaining to his claim. The facts are now recognized without prejudice on the one side and he is no longer accused of flagrant insincerity on the other. The Elisha Gray myth has now pretty much passed into the Valhalla of History along with the other myths, where they enjoy due recognition for their worth unhampered by any too literal allegiance to the more prosaic facts.

But one myth seems still to cling to earth,—the myth of Joshua Coppersmith. May he, too, soon go to "the bourne from whence no traveler returns"! Even there however he may have bad luck and be relegated to the stables to groom the horses, the winged steeds on which the others ride gleaming through the sunlit heavens.

William Chauncy Langdon

Notes on Recent Occurrences

OVERSEAS SERVICE EXTENDED TO CANAL ZONE, PANAMA, COSTA RICA, THE PHILIPPINES AND THREE CITIES IN PALESTINE

TELEPHONE service between the United States and the Republic of Panama and between the United States and the Panama Canal Zone was opened on February 24, and between the United States and the Republic of Costa Rica on March 20, by conversations between officials of the respective governments. On March 30 telephone service was opened between the United States and the Philippine Islands. Jerusalem, Haifa and Jaffa in Palestine were brought within reach of American telephone users on April 7.

These services embrace all Bell and Bell-connecting telephones in the United States, Canada, Cuba, and Mexico. The connecting links to the telephone systems of Panama, the Canal Zone, and Costa Rica are radio telephone circuits from the American Telephone and Telegraph Company's new short-wave station at Miami, Florida, to the station of the Tropical Radio Telegraph Company near Panama City and to that of the International Radio Company near San Jose. These are the fourth and fifth services to open through the Miami station, extension having been recently made to the Bahamas, Colombia, and Venezuela. The charge for a 3-minute call between New York and the Republic of Panama or the Republic of Costa Rica is $21. Charges to the Canal Zone are the same.

Telephone connection with the Philippine Islands is established through short wave radio telephone stations near San Francisco and Manila. The opening of service to the Philippines marks the second step in the expansion of Bell System telephone service across the Pacific. Connection with the Hawaiian Islands through the California stations was made late in 1931. Tests are already in progress looking to the eventual establishment of service with Japan and other points in the Far East.

A three-minute conversation between San Francisco and Manila costs $30. Charges for calls with cities in the Middle West and East are greater, depending on the distance involved. The service includes all Bell and Bell-connecting telephones in the United States, Canada, Cuba and Mexico.

Jerusalem, Haifa and Jaffa, in Palestine, are reached by connecting the regular transatlantic radio telephone circuits with a short wave channel between London and Cairo, Egypt, and land wire facilities out of Cairo. This service, also, embraces all Bell and Bell-connecting telephones in the United States, Canada, Cuba and Mexico. A three-minute conversation between New York and Palestine costs $37.50.

PUBLIC RELATIONS CONFERENCE

A CONFERENCE of Bell System officials and department heads in charge of public relations was held at New York from March 7 to March 9, inclusive, under the leadership of Arthur W. Page, Vice President of the American Telephone and Telegraph Company. Other participants from that company included President Walter S. Gifford, Vice-Presidents E. F. Carter and Bancroft Gherardi, S. L. Andrew, Chief Statistician, K. S. McHugh, Commercial Engineer, and members of the Information Department.

ANNUAL MEETING

THE annual meeting of the stockholders of the American Telephone and Telegraph Company was held on Tuesday, March 28th. The Board of Directors was re-elected There had been no change since the preceding annual meeting in the number of shares of stock outstanding, 18,662,275, although the number of stockholders had increased by nearly 33,000.

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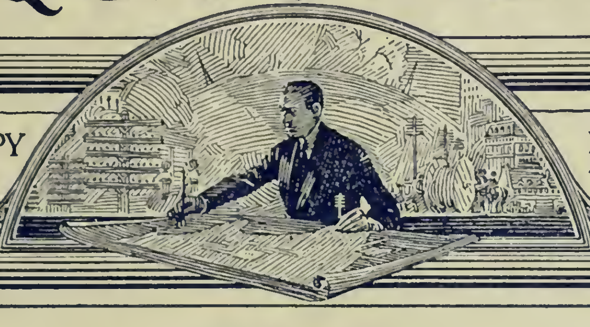

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The Telephone Fights an Earthquake

"NUMBER 108—your call to Seattle is ready.—Number 109—your call to Chicago is ready—" The loud-speaker boomed out the announcement. A man, a woman, pushed forward. They showed their numbered cards to the American Legion men holding back the crowd,—sometimes more than 500 people,—and were admitted to the front yard where temporary telephones were arrayed on tables. A few quick words over the emergency circuits and the anxiety of friends and relatives far away was allayed. There are people in the California earthquake zone who will not soon forget the open-air long distance telephone office that put them in touch with the outside world.

The cry of "tidal wave," fortunately unjustified, drove many to flee to the hills on that fatal Friday when much of Southern California quivered and shook. A family living across the street from the long distance telephone office in Long Beach gave permission, before they left, for the telephone company to use their yard. When they returned, they found tables on the porch, and shelves, benches, tables and telephones covering the whole front lawn. Here operators, sheltered by a canvas-covered framework, handled a deluge of calls. Perched high above the operators was a telephone man announcing through a loud-speaker the number and destination of each call as the connection was set up: "Number 116—your call to Des Moines is ready,"—

An Ominous Rumble and Roar

It was late in the day of the 10th of this past March, 5:54 P.M. to be exact, that the earthquake struck,—unannounced, unanticipated and unaccompanied save by an ominous rumble and roar. Communities extending from Santa Barbara to

San Diego felt the temblor, although it was most severe in parts of Los Angeles and Orange Counties. Approximately 120 people lost their lives in the disaster, most of whom were pedestrians caught on the sidewalks by walls falling from poorly constructed buildings.

The shock was most pronounced in the vicinity of south Los Angeles, Compton, Long Beach and Santa Ana. The Bell System operates the exchanges in this area except for local service at Long Beach which is handled by the Associated Telephone Company, Ltd. Approximately 75,600 telephones were in the area seriously damaged by the earthquake.

Probably no other type of natural phenomenon produces greater nervousness and tendency towards hysteria than a sudden earthquake with no apparent warning. Only those who have experienced earthquakes can appreciate this and can fully realize how much courage it takes to stay at a switchboard or other post of duty during a severe earthquake.

Switchboard in Contortions

Loyalty to public service again came to the surface when the earthquake struck. At Long Beach, the Bell System long distance office was being operated by about twenty girls. All out-going calls from the city are handled by this center. When the shock came they stood back while the switchboard appeared to go into contortions. The lights went out for eighteen minutes, but the operators stuck to their posts handling calls for half an hour. Later they were directed to leave the building following subsequent shocks. Protests from the girls arose, but they finally left the board.

The Traffic Superintendent remained and completed some emergency calls received over the switchboard and from Long Beach city officials and others who came into the operating room to place calls. Emergency calls were put through for the police, hospitals, Army, Navy, Marines, the National Guard and to the press. At about 8:00 P.M. the operators

Temporary Telephone Service for the General Public Was Installed Across the Street from the Long Beach Toll Office. There were five hundred people around this installation the morning after the earthquake.

An American Legion Man Directing a Customer to the Telephone as It Was Announced through the Loud Speaker that His Long Distance Call Was Ready.

The Outdoor Temporary Structure and Some of the Operators Who Were Giving Service at Long Beach After the Earthquake.

One Corner of the Long Beach Outdoor Emergency Telephone Headquarters Equipped with Subscriber Magneto Sets through Which Calls from the Stricken Area Were Passed by Operators to the Los Angeles Long Distance Terminal, Thirty Miles Away.

again volunteered to go to work at the switchboard. At 8:45 P.M., following further shocks, they were directed again to leave. Newspaper reporters, policemen and a few other officials once more ventured into the shaking operating room, and several important calls were thus completed by using operators' telephone headsets.

"GET THE MESSAGE THROUGH"

In those first few hectic hours of the catastrophe no one knew the actual extent of damage done. Had telephone people known that the central office buildings had structurally withstood the jarring of continued shocks, and that not a single telephone employee on duty was to be seriously injured, they might have breathed more easily. But though they were ignorant of the extent of the disaster, there was no slackening in the drive to restore communication service within the stricken area and to the outside world. The courage and efficiency displayed by the operating, engineering, maintenance and transportation forces were everywhere in evidence.

Throughout Southern California, telephone people rushed voluntarily to headquarters to report for duty. This in itself took courage. Nobody knew what subsequent shocks, already in progress, might bring to their loved ones. Even former employees and operators visiting from Eastern States appeared at the central offices and volunteered their services. There were instances, too, of telephone company people reporting for duty despite injury to their relatives and demolition of their homes. Many employees were on duty forty-eight hours and more without rest. Both men and women refused to relinquish their posts.

At headquarters of the telephone company in Los Angeles, reports of the damage to buildings, equipment and plant were quickly gathered from the various districts. Urgent needs were cared for immediately and a co-ordinated plan of action was developed by the heads of the departments for Long Beach where the situation was most serious.

The building service personnel did great work in obtaining damage reports, clearing the operating rooms of debris, stopping the flow from broken water and gas connections. In a similar manner, the motor vehicle personnel rushed into the stricken districts, while they were still quaking, with emergency lighting units, drinking water, automobile storage batteries lumber and food supplies. They later established a regular transportation schedule. Many of the operators at Compton and Long Beach depended entirely upon the company for drinking water and meals. Company commissaries were established at Compton, Long Beach and Santa Ana.

As the reports poured in, it was evident that the telephone system was affected, but that service to most Southern California points was not stopped and could not be stopped, even by a severe earthquake. Of telephone property, outside plant suffered the least damage, followed by equipment, then buildings. Considering the extent of the earthquake area, however, the damage was comparatively small.

Well-constructed Buildings Stand Up

The extent of damage to buildings in general in the earthquake area was considerably affected by the condition and type of soil of the building sites. Where there was a solid underlying formation of rock, gravel, or hard clay, there was less damage than in those cases where a deep subsoil of loose alluvium existed.

Buildings which had been well constructed upon modern and scientific lines structurally withstood the shocks and escaped with only minor damage. Steel and reinforced concrete construction, for example, suffered little damage, while many small buildings of inferior construction were wrecked. Standing out as examples of modern construction, the Bell System buildings distinguished themselves by withstanding the temblor and resisting structural damage. Although the steel frame of the Lafayette building swayed, cracking walls and breaking partitions, neither the frame nor any of the steel connections were loosened or sprung by the movement. In the same manner, the reinforced concrete buildings at Santa Ana and Compton remained unweakened with no damage to the structural frame. The telephone company buildings of the small frame and stucco type, housing the unattended dial offices at Garden Grove and Placentia, both in the severely shaken area, were not damaged.

Damage to buildings which actually did occur, while often very serious and spectacular in nature, was limited to a small proportion of the structures in the affected area. In the case of telephone buildings, the Bell System long distance office building and the Associated Telephone Company's local exchange buildings in Long Beach were subjected to very severe shock. The Bell System building, upon which the telephone communication from the stricken area to the outside world depended, was badly shaken and in this case the engineers provided protection and bracing to ensure against any possible contingency.

In the post mortem of Los Angeles telephone building damage, it is of interest to note the difference between the effects of the shock on the Lafayette and Thornwall central office buildings, one located about three and one-half miles east of the other, and both placed with their longer dimensions on an east-west line. The north and south walls of the Lafayette building were affected the greatest by cracks, while the east and west walls of the Thornwall building suffered most. The earthquake movements were in varying directions in different sections of the area.

TELEPHONE EQUIPMENT SEVERELY SHAKEN

What happened to the central office equipment, particularly in the Los Angeles dial system offices, is another interesting story. The heavy cabinets holding the line switchboards were jolted from six to eight inches out of line, but the equipment continued to function. Distributing frames and relay racks with their thousands of wires were ripped loose from their moorings in the concrete floors, yet the telephone circuits were not broken. The glass doors on the line switchboards were thrown open in places and the glass in some was shattered. Selector frames were thrown out of alignment in the Lafayette building. The slate fuse panels on nearly all of these frames were cracked at the corners where they are bolted to the frame uprights. Cable racks were bent or pulled out of line in two places where they were connected by a brace to a sidewall or a column. Marks on one column indicated there had been a lateral motion of approximately sixteen inches between the building column and the cable rack. In the Thornwall building, one cable rack was sheared loose from its support over a distance of about thirty feet.

In 1925, telephone engineers found central office storage batteries moved out of line and their connections broken after an earthquake in the Imperial Valley. Contemplating the possibility of a repetition of this trouble, an emergency battery support, to receive the batteries if shaken from their standard insulator supports, was designed and provided in most of the central offices. Following this earthquake, it was noted with satisfaction that the tons of storage batteries in two of the Southern California telephone buildings, shifting sidewise, had been caught and held by the supporting framework "just as they should," thus saving many sections from possible serious service interruptions in the great emergency.

In several locations where glass batteries were broken, serious service interruptions were avoided by the use of automobile batteries and emergency charging and lighting equipment.

WIRES VIBRATE LIKE JUMPING-ROPES

Damage to outside plant was limited largely to that resulting from falling walls and the greater portion of the maintenance work was caused by crosses, short circuits and broken wires. Compton suffered more damage in this respect than any other exchange of the Southern California Telephone Company. The major business street was damaged to such an extent that practically all occupants moved their establishments into the Oil Exhibition Building at the north end of town, making it necessary to place about 1700 feet of cable to provide service. One section of 400-pair cable was destroyed by the falling walls of an adjacent building. In telephone lines, ordinarily taut, the poles nodded at each other and the wires vibrated like jumping-ropes during the first temblor.

Although there was no material damage experienced in the toll lines, it was necessary to clear many "crosses" and short circuits caused by swinging wires. In the Santa Ana-Newport Beach-Long Beach area, the lines had just been cleared when another shock repeated the trouble, making it necessary again to untangle the lines by climbing the poles and shaking the wires clear.

Some small amount of damage occurred in the underground plant due to displacement of cables.

EVERYBODY TRIES TO TELEPHONE AT ONCE

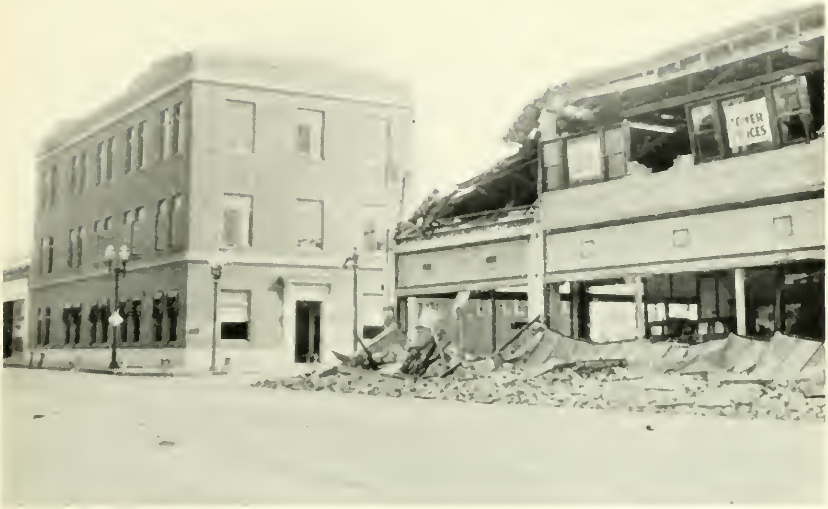
The problem of handling an amount of telephone traffic even beyond the capacity of the equipment was almost as great as the problem of plant repair. Immediately following the earthquake the traffic load increased to several times its normal volume. This was in addition to the false signals created when receivers were knocked from hooks and open wires crossed and short-circuited. Fuses were blown by the overload in Los Angeles, Thornwall and Vermont offices, causing interruptions of short duration.

At Long Beach, the system of temporary facilities, referred to at the beginning of this article, which was like that employed after the Santa Barbara earthquake some years ago, was placed in service at 7:00 A.M., on the day after the earthquake. By 11:00 A.M. all of the equipment available was in place and the traffic was moving with dispatch. About forty magneto type telephones were placed on shelves in the temporary structure. These were connected to Los Angeles toll circuits through a cable suspended from a tree, and were attended by toll operators. Connected in multiple with each of these telephones was a desk type instrument placed on a long shelf at the street curb for the use of patrons. Their calls were recorded at a counter across the front of the temporary office, and check numbers assigned to each call serially were given to the customer. Tickets were passed from the recorders to the line operators seated at the magneto telephones. When the called party was reached, or a report received, the operator notified a messenger who gave the information to the announcer.

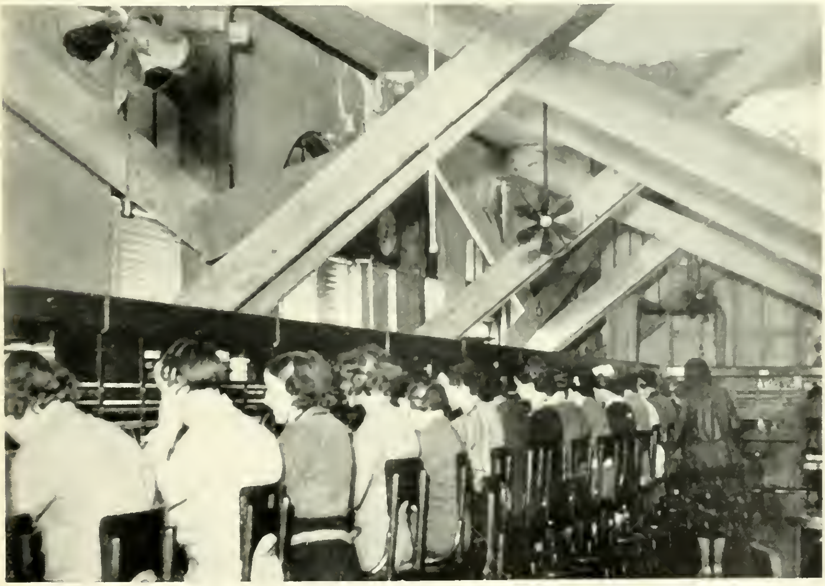
Hundreds of calls went out from this point during the first day. For hours it was one of the focal spots in Long Beach.

Toll switchboard service was again started at 10:00 A.M. Saturday after the bracing of the telephone building was in place. With exception of the period between 12:00 and 1:00 P.M. when service was affected by false rumors of another impending earthquake and a tidal wave, the traffic flowed through in good order. The service through the outdoor temporary exchange was continued through Saturday, Sunday and Monday. The average business day messages originating in this office for the month of February, 1933, was 5,823. The messages completed through the regular and temporary offices following the earthquake compared as follows:

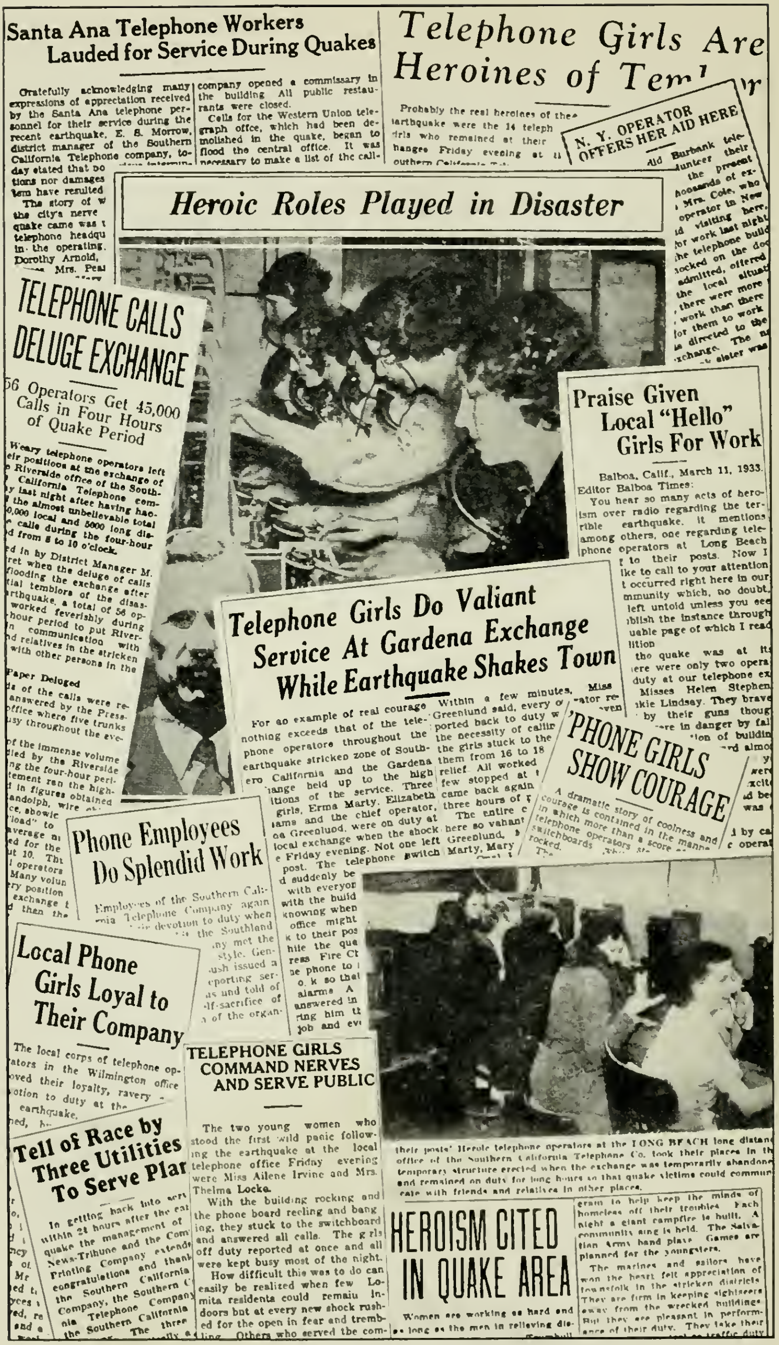
Saturday	2,383	(Day following earthquake)
Sunday	6,625	
Monday	10,254	
Tuesday	9,639	
Wednesday	8,640	
Thursday	8,397	



A STUDY IN BELL SYSTEM BUILDING CONSTRUCTION. The three-story Santa Ana telephone building stood the earthquake with only minor damage while the automobile showroom across the street went crashing down.



"BUSINESS AS USUAL" IN THE BELL SYSTEM LONG BEACH OFFICE. These girls worked during the after-shocks in this room so braced that should another earthquake occur the walls could have collapsed and left the floors and ceilings of the three-story building intact.



Santa Ana Telephone Workers Lauded for Service During Quakes

Gratefully acknowledging many expressions of appreciation received by the Santa Ana telephone personnel for their service during the recent earthquake, E. S. Morrow, district manager of the Southern California Telephone company, to-
day stated that no
tions nor damages
tem have resulted
The story of w
the city's nerve
quake came was t
telephone headqu
in the operating.
Dorothy Arnold,
Mrs. Peai

company opened a commissary in the building All public restaurants were closed.

Calls for the Western Union telegraph office, which had been demolished in the quake, began to flood the central office. It was necessary to make a list of the call-

Telephone Girls Are Heroines of Tem

Probably the real heroines of the
earthquake were the 14 teleph
irls who remained at their
hanges Friday evening at tl

N. Y. OPERATOR OFFERS HER AID HERE

Aid Burbank tele-
lunteer their
the present
housands of ex-
Mrs. Cole, who
operator in New
id visiting here,
for work last night
the telephone build
nocked on the do
admitted, offered
the local situat
, there were more
, work than there
for them to work
is directed to the
xchange. The n
sister was

Heroic Roles Played in Disaster

TELEPHONE CALLS DELUGE EXCHANGE

56 Operators Get 45,000 Calls in Four Hours of Quake Period

Weary telephone operators left
eir positions at the exchange of
e Riverside office of the South-
California Telephone com-
y last night after having han-
the almost unbelievable total
0,000 local and 5000 long dis-
calls during the four-hour
d from 6 to 10 o'clock.
ed in by District Manager M.
ret when the deluge of calls
flooding the exchange after
tial temblors of the disas-
rthquake, a total of 56 op-
worked feverishly during
hour period to put River-
n communication with
nd relatives in the stricken
with other persons in the

Paper Deluged

ds of the calls were re-
answered by the Press-
office where five trunks
usy throughout the eve-
of the immense volume
dled by the Riverside
ng the four-hour peri-
tement ran the high-
d in figures obtained
andolph, wire
ce, showin
"load" to
verage ar
ed for the
ut 10. The
l operators
Many volun
ery position
exchange t
d then the

Praise Given Local "Hello" Girls For Work

Balboa, Calif., March 11, 1933.

Editor Balboa Times:

You hear so many acts of heroism over radio regarding the terrible earthquake. It mentions among others, one regarding telephone operators at Long Beach
g to their posts. Now I
ike to call to your attention
t occurred right here in our
mmunity which, no doubt,
left untold unless you see
ublish the instance through
uable page of which I read
lition
the quake was at its
ere were only two opera
duty at our telephone ex
Misses Helen Stephen
kie Lindsay. They brave
by their guns thoug
ere in danger by fal
ion of buildin
d almo
y
were
xcit
d be
was
d by ca
e operat

Telephone Girls Do Valiant Service At Gardena Exchange While Earthquake Shakes Town

For an example of real courage
nothing exceeds that of the tele-
phone operators throughout the
earthquake stricken zone of South-
ern California and the Gardena
change held up to the high
itions of the service. Three
girls, Erma Marty, Elizabeth
iams and the chief operator,
na Greenlund, were on duty at
local exchange when the shock
e Friday evening. Not one left
post. The telephone switch
d suddenly be
with everyon
with the build
knowing when
office might
k to their pos
hile the qua
ress Fire Ch
ne phone to
o. k so that
alarms A
answered in
ring him th
job and eve

Within a few minutes, Miss
Greenlund said, every o
ported back to duty w
the necessity of callir
the girls stuck to the
them from 16 to 18
relief. All worked
few stopped at
came back again
three hours of
The entire c
here so valiant
Greenlund,
Marty, Mary

ator re-
ven

'PHONE GIRLS SHOW COURAGE

A dramatic story of coolness and
courage is contained in the manne
in which more than a score of
telephone operators st
switchboards
rocked.

Phone Employees Do Splendid Work

Employees of the Southern Cali-
fornia Telephone Company again
their devotion to duty when
the Southland
any met the
style. Gen-
ush issued a
eporting ser-
as and told of
elf-sacrifice of
of the organ-

Local Phone Girls Loyal to Their Company

The local corps of telephone op-
ators in the Wilmington office
oved their loyalty, ravery
otion to duty at the
earthquake.
ned,

TELEPHONE GIRLS COMMAND NERVES AND SERVE PUBLIC

The two young women who stood the first wild panic following the earthquake at the local telephone office Friday evening were Miss Ailene Irvine and Mrs. Thelma Locke.

With the building rocking and the phone board reeling and banging, they stuck to the switchboard and answered all calls. The girls off duty reported at once and all were kept busy most of the night.

How difficult this was to do can easily be realized when few Lomita residents could remain indoors but at every new shock rushed for the open in fear and trembling. Others who served the com-

Tell of Race by Three Utilities To Serve Plar

In getting back into serv
within 24 hours after the ea
quake the management of
News-Tribune and the Com
Printing Company extends
congratulations and thank
the Southern California
Company, the Southern C
nia Telephone Company
the Southern California
The three

their posts' Heroic telephone operators at the LONG BEACH long distan
office of the Southern California Telephone Co. took their places in th
temporary structure erected when the exchange was temporarily abandone
and remained on duty for long hours so that quake victims could commun
cate with friends and relatives in other places.

HEROISM CITED IN QUAKE AREA

Women are working as hard and
as long as the men in relieving dis-

gram to help keep the minds of
homeless off their troubles. Each
night a giant campfire is built. A
community sing is held. The Salva-
tion Army band plays. Games are
planned for the youngsters.

The marines and sailors have
won the heart felt appreciation of
townsfolk in the stricken districts
They are firm in keeping sightseers
away from the wrecked buildings
But they are pleasant in perform-
ance of their duty. They take their

California Newspapers Praise the Work of the Telephone Operators in the Emergency

Another temporary toll office of eight stations, similar to that described for Long Beach was established in a lot adjacent to the Compton central office and many emergency calls were handled there.

Telephone Workers Earn Praise

Bell System wheels moving fast and Bell System minds in co-operative action were responsible for maintaining vital emergency service and many other valuable acts of public assistance rendered during the time of stress. The Associated Telephone Company people did valiant work in clearing the damage to their plant and service. No particular department of the telephone organization could be cited singly for loyalty and heroism. As this catastrophe has proven, it will take more than an earthquake to cripple for very long, or seriously, the service and spirit of the telephone family. That the many heroic deeds of the members of the organization were appreciated is evidenced by the tributes to operators, repairmen, supervisors and others, which immediately came from radio broadcasting stations, from the press, from individuals who received the service and from telephone company executives.

Under the heading "A Cheer for the Hello Girl," the *Los Angeles Record* said in part:

> Following the Long Beach earthquake there came the usual stories of heroism by telephone girls. It's an old story. Never was there a disaster yet that the girls didn't stick, through flood and fire, through danger and dread.
>
> Around Long Beach girls worked 48 hours at a stretch, in front of rocking switchboards, getting messages through. And all honor to them.

Editorial comment in the *Inglewood Californian* pointed out that

> There were many unsung heroines and heroes working silently and efficiently to keep telephone service as near normal as possible during one

of Southern California's most appalling emergencies—our recent earthquake visit.

More long distance calls were handled in Southern California during that Friday night and the next day than in any 24 hours in the history of the telephone company. It is creditable that so many were handled so efficiently.

Speaking of the telephone operators, the *Santa Ana Bulletin* said editorially:

> While the city was tumbling down, these workers stayed at their posts and put through calls as rapidly as equipment would permit. They never faltered, even though the quakes continued to jostle them. It is nearly always the same in every disaster, the telephone girls stick to their jobs. They deserve the highest praise.

In like vein, the *Santa Ana Register* summed up the feeling of the public in the following editorial:

COMMUNITY GRATEFUL FOR TELEPHONE SERVICE

> The telephone operators who remained at their posts, so that all through Friday night, while temblors continued to rock this section, calls were taken and put through wherever possible, are deserving of particular congratulation. For two types of calls the services of the operators were most appreciated. The first was the emergency calls for necessary aid, the second was the calls from individuals to those dear to them. Following the first shock, the principal thought in everyone's mind was to get in touch with those whose welfare is paramount in the mind and heart of the individual.
>
> For a period Friday night, we were out of touch with a telephone, with the family scattered. It added immeasurably to our morale when we got back again where there was a telephone. The experience was undoubtedly multiplied a thousand-fold at that time. The community is appreciative of the telephone service throughout this crisis and congratulates the personnel upon which it depended.

It is costly wisdom that is bought by experience, but the knowledge that Southern California telephone people obtained from the earthquake may be valuable for the future. Southern California Bell System employees hope that their fellow workers in other sections of the country will not have a repetition of these troubles of last March.

H. W. HITCHCOCK

(The author desires to emphasize the fact that while this paper was prepared under the supervision of the Engineering Department, it represents the combined effort of many individuals in many departments of the Company.)

Perfect Transmission and Reproduction of Symphonic Music in Auditory Perspective

Foreword

THE demonstration in Constitution Hall, Washington, on April 27th, of the perfect transmission and reproduction in full auditory perspective of a symphony concert produced in Philadelphia by the Philadelphia Orchestra and transmitted to Washington over underground telephone wires, marked the completion of several years' work by the research and engineering forces of the American Telephone and Telegraph Company and Bell Telephone Laboratories.

Sponsored by the National Academy of Sciences as a noteworthy scientific achievement and directed and controlled as to artistic and tonal effects by Dr. Leopold Stokowski, Director of the Philadelphia Orchestra, the transmitted program was listened to by a distinguished audience of musicians, scientists, musical critics and music lovers which filled the hall to capacity. The prolonged applause which followed each of the symphonic numbers and the several experiments made by Dr. Fletcher in demonstration of the capabilities of the system were proof of satisfactory accomplishment.

Not only did the concert demonstrate the possibility of perfect reproduction in full auditory perspective, but likewise the capability of the reproducing apparatus to give tonal effects far beyond the capability of any human orchestra. This was illustrated on the one hand in the pianissimo passages of "L'Après Midi d'un Faun" where the volume of sound was reduced to the very threshold of hearing without the introduction of any extraneous noise. At the other extreme the crashing passages in the finale of Götterdämmerung were carried in loudness almost to the point where pain takes the place of hearing. In this latter number the lighting accompaniments which Electrical Research Products Incorporated had prepared for each number, to provide something pleasing for the eye, were particularly effective.

To accomplish the results obtained, multi-channel transmission was required. Actually three separate circuits were employed. Each circuit was capable of handling the entire frequency and volume range and each did in fact carry something of all that was produced. Because of the arrangement of pick-up microphones in Philadelphia and loudspeakers in Washington, most of the sound produced on the left-hand side of the stage in Philadelphia was transmitted over one circuit to a loudspeaker on the left-hand side of the stage in Washington. Similarly sounds produced in the center and on the right-hand side of the stage went mainly over separate circuits to properly placed loudspeakers in the center and right of the stage at Washington.

Each transmission circuit was capable of transmitting the entire range of frequencies from 40 to 15,000 cycles per second. Further the attenuation of all frequencies within this entire range, which is about three times the width of the bands used in radio broadcasting, had to be substantially the same; otherwise distortion would have been inevitable. Likewise each circuit had to be free from all electrical disturbances since their presence would have produced objectionable noise in the loudspeakers.

Thus while the wires used were those normally provided for telephone service, they had to be specially treated with frequency equalizing and noise preventing apparatus and with specially constructed and installed amplifiers.

The several pick-up microphones used at Philadelphia were designed to give a uniform flat response over the entire frequency and volume range. The power amplifiers employed at

Washington were designed not only to handle without distortion the full volume of energy required in fortissimo passages, but likewise the pianissimo passages without the introduction of noise. All of the power amplifiers were controlled by apparatus located in the conductor's box in the rear of Constitution Hall. These controls admitted of handling each channel separately or all together, as Dr. Stokowski elected. He was also provided with a talking circuit to Conductor Smallens in Philadelphia and a tempo circuit. Thus the whole performance was remotely controlled by a conductor in the rear of his audience and so in position to judge and regulate exactly the sounds to which they were listening.

Among the most extraordinary parts of the entire assemblage of apparatus were the loudspeakers. Like the microphones, lines, line and power amplifiers, they had to handle with complete fidelity the entire broad band of frequencies. Also they had to translate from electrical to sound energy, power which at times rose to as much as 150 watts per loudspeaker, and to distribute all sounds uniformly throughout the auditorium. The ordinary loudspeaker, such as is used in radio broadcast receivers, has a tendency to concentrate the higher frequencies in beams.

Since roughly half the energy of an orchestra is in the register below 300 cycles per second and half in the register from 300 to 15,000 cycles per second each loudspeaker was constructed of three separate units. One of these units was a large affair capable of handling all frequencies up to 300 cycles per second. The other two were identical and handled all frequencies above this point. Two units of this type were used to give a proper directional distribution of the higher frequencies. Division of the frequencies between the units of each type was accomplished by suitable band pass filters.

Technically the operation of the system in all its parts leaves little to be desired. Certain minor modifications, particularly with regard to refinement of the controls, are indicated and considerable further work in the matter of making the several parts of the equipment suitable for regular use is required. It is certain, however, that a new instrument for the dissemination of high quality music and for the production of musical effects not hitherto attainable has been produced. How far it will be utilized is largely in the hands of the musical world. It would seem, however, that it should very greatly stimulate the development of symphonic orchestras since a widened audience should enlarge the support requisite for their maintenance.

F. B. Jewett

Part I. The Demonstration

Perfect reproduction of orchestral music with the illusion of hearing each separate instrument from its proper position on the stage, is now a practical accomplishment. The announcement on April 27, 1933, that a symphony concert played in Philadelphia had been so reproduced in a Washington auditorium attracted active interest, particularly among scientists and musicians. Reproduction of music by radio and in sound pictures is a commonplace of the day, and many people have become accustomed to these less than perfect reproductions. For many purposes such imperfect reproductions are quite satisfactory. The difference between a perfect and the more usual reproductions may be illustrated by a photographic analogy. A good photograph is a satisfactory record of a scene, but for a perfect reproduction, the true coloring would have to be portrayed, and the photograph would have to be taken so that it could be viewed through a stereoscope. Similar requirements must be met for perfect reproduction of music. Two of them, that both the complete frequency and complete volume ranges be transmitted, have been generally recognized for some time. The third, that the sounds must be reproduced with the correct auditory perspective, has been fully apprecithey needed opportunity to utilize music in its more perfect forms. Now it happened that Dr. Leopold Stokowski, Director of the Philadelphia Orchestra, was interested in the possibilities of electrical systems for the production of exceptional orchestral effects. Through his voluntary co-operation, therefore, the Laboratories' scientists were able to make quantitative physical studies of music as rendered by his orchestra, and so to perfect their designs; and with the completion of the new equipment some of the possibilities which Dr. Stokowski had hoped for became practicable. An extended series of tests was then carried on in Philadelphia in which the Laboratories' scientists were generously assisted by Dr. Stokowski. As a result of these studies, it was found that by employing two microphones, one properly located on each side of the orchestra stage, and by transmitting over two separate circuits to two of the newly developed loud speakers placed at opposite sides of the listening stage, the illusion of actual presence of the orchestra could be satisfactorily produced. The addition of a third system, with microphone and loud speaker located centrally on the stages, enhanced the realism to some extent, particularly for certain sections of the auditorium.

Even with the discovery of a comparatively simple means of obtaining true auditory perspective, the problem was not completely solved. Never before had either the complete frequency, or the complete volume range, of a symphony orchestra been commercially transmitted and reproduced. There was available no complete chain of apparatus, from microphone to loud speaker that would faithfully transmit the entire range of frequency and volume. Microphones offered the fewest difficulties. Bell Laboratories had already designed sensitive microphones that would transmit practically the entire range required, and only minor modifications were needed to make them entirely suitable.

This was not true of the amplifiers. There had to be developed amplifiers which would faithfully transmit all frequencies from 40 to 15,000 cycles at levels from the barely audible pianissimo effects to the resounding orchestral crashes of three million times greater power; and all the pieces of apparatus had to be so designed that even during intervals of complete silence not the slightest noise would be introduced to suggest the presence of electrical apparatus. No underlying hum or noise such as is commonly present in other systems of reproduction, could be tolerated with the new apparatus. In the intervals of silence there must be real silence: a dead auditory void in which the fall of a pin could be heard. This has actually been accomplished to a degree heretofore unknown with amplifiers operated entirely on alternating current. When audience and orchestra were at their quietest, no noise was added by the transmission system.

Of even greater difficulty, possibly, was the design of suitable loud speakers. It is not practicable to obtain the entire frequency range with a single unit, and so two types of loud speakers are used. One is employed for the frequencies from 40 to 300 cycles; and another type, for the range from 300 to 15,000 cycles. These loud speakers are different from anything previously produced commercially. Never before have these elements fulfilled such difficult requirements of frequency range and volume or converted so much of the electrical energy into sound power. The best present sound picture systems record and reproduce approximately half the range of frequencies handled by the new loud speakers. In volume range the comparison is equally remarkable. Sound picture systems under the most favorable conditions may provide a volume range of 40 to 45 db, corresponding to a power range of 10,000–30,000 to 1. The range provided by the new apparatus is 80 db, corresponding to a power range of 100,000,000 to 1.

The new loud speakers and their associated equipment of amplifiers and microphones are, therefore, fully capable of handling the entire volume range of a symphony orchestra. When one speaks of range of loudness which can be handled they needed opportunity to utilize music in its more perfect forms. Now it happened that Dr. Leopold Stokowski, Director of the Philadelphia Orchestra, was interested in the possibilities of electrical systems for the production of exceptional orchestral effects. Through his voluntary co-operation, therefore, the Laboratories' scientists were able to make quantitative physical studies of music as rendered by his orchestra, and so to perfect their designs; and with the completion of the new equipment some of the possibilities which Dr. Stokowski had hoped for became practicable. An extended series of tests was then carried on in Philadelphia in which the Laboratories' scientists were generously assisted by Dr. Stokowski. As a result of these studies, it was found that by employing two microphones, one properly located on each side of the orchestra stage, and by transmitting over two separate circuits to two of the newly developed loud speakers placed at opposite sides of the listening stage, the illusion of actual presence of the orchestra could be satisfactorily produced. The addition of a third system, with microphone and loud speaker located centrally on the stages, enhanced the realism to some extent, particularly for certain sections of the auditorium.

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The new loud speakers and their associated equipment of amplifiers and microphones are, therefore, fully capable of handling the entire volume range of a symphony orchestra. When one speaks of range of loudness which can be handled by an electrical system for reproduction, one is concerned with the differences between the loudest and faintest passages of the music which it can reproduce. There is in addition the problem of handling the peaks of maximum loudness. These peaks in the case of music from a symphony orchestra are beyond the possibilities of the ordinary system to reproduce without distortions which seriously affect the musical sonority. The low frequency sounds make the largest contribution to the peaks of sound power which must be handled to meet these conditions. The diaphragm of the low frequency element in the new loud speaker has been made nearly seven times larger than that of the elements used ordinarily for sound picture reproduction. By these diaphragms a large column of air is set into motion.

The ordinary loud speaker also becomes directional in its characteristics at the higher frequencies. Low frequency sounds spread in all directions from the mouth of the horn, but the higher frequencies tend to concentrate into a beam projected directly ahead of the horn; and the width of the beam becomes narrower and narrower as the frequency increases. Because of this fact, the audience in a large hall equipped with the ordinary loud speakers, never hear quite the proper blending of frequencies. Those directly in front of the horn receive too great a proportion of the higher frequencies, while those on the sides receive too much of the low frequencies. To avoid this effect, the horn of each high-frequency element is divided into 16 diverging rectangular sections which spread the sound over an arc of 60 degrees vertically and one of 60 degrees horizontally. Two of these units placed side by side thus spread the sound over a horizontal angle of 120 degrees—a far wider coverage than has been obtained before and one which distributes the sound throughout the auditorium with a faithful blending of the frequencies.

Besides providing for the full volume range of the orchestra, the amplifiers and loud speakers have an additional power capacity of at least 10 db, so that, if desired, the volume of loud passages may be made ten times as great as the actual output of the orchestra. Technically described, the maximum sound power of a symphony orchestra integrated over an interval of two-tenths of a second is less than 20 watts, whereas that possible from the loud speakers of the new apparatus is more than 200 watts. This additional capacity allows effects to be obtained which have been impossible before. Besides the effects of range and quality of tone, the total aesthetic appeal of an orchestra is due in no small degree to the range in volume. The number of musicians one can place on a stage is limited. To increase the size of a modern symphony orchestra by ten times is impossible in any existing hall. Since it is relatively simple to place the amplification control before the director, however, the new apparatus enables the director to secure at will the equivalent of an orchestra of nearly a thousand musicians, or to reduce the volume to any desired degree. He is thus able to produce sounds louder than the orchestra alone, or to make faint sounds even fainter than the performers play them, or to change the rate at which crescendos build up and diminuendos die away.

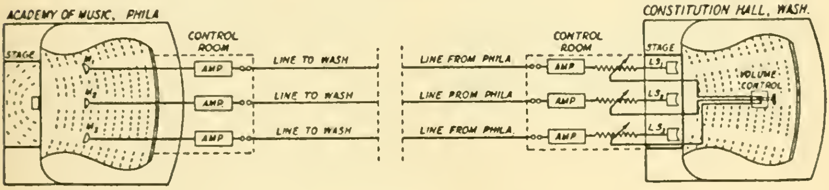
The advantage of this control of volume does not end here, however. Its presence makes it possible to reproduce operatic music, where a soloist is accompanied by an orchestra, without allowing the voice of the singer to be drowned out by the louder orchestral passages. For this purpose another channel, including its separate microphone, transmission line and loud speaker, can be provided primarily for the singer. The volume of output of this channel is controllable independently of the others. In this way the loudness of the voice may always be kept above that of the orchestra and the desired musical effect be obtained, with the singer able to concentrate upon the beauty rather than the loudness of the voice.

It is also practicable to introduce quality as well as volume control into the circuit to be used by the director. In this way he can regulate the bass or overtone content of the music independently of the loudness to a much more marked degree than is possible with the instruments themselves. There thus reside in the new apparatus possibilities heretofore unattainable; and telephonic research has laid a foundation for what may be an important advance in musical aesthetics.

The first public demonstration of the new apparatus was given in Washington on the evening of April 27, 1933 under the auspices of the National Academy of Sciences. At that time Dr. Stokowski, Director of the Philadelphia Orchestra, manipulated the controls from a box in the rear of Constitution Hall, while the Philadelphia Orchestra, led by Associate Conductor Alexander Smallens, played in the Academy of Music at Philadelphia. Between Philadelphia and Washington, the music was transmitted over telephone cable circuits. The program consisted of the Toccata and Fugue in D Minor, of Bach; Beethoven's Symphony No. 5 in C Minor; L'Après-midi d'un Faun of Debussy; and the Finale of Götterdämmerung, with Miss Agnes Davis as Brünhilde. A visual accompaniment was provided for the music by Electrical Research Products, Incorporated. Its stage direction—through the courtesy of the Yale School of Drama—was by S. R. McCandless, and the designs were by Eugene Savage and George Davidson.

For this demonstration three circuits were used, left, center, and right. Except for the "Götterdämerung" music the three channels, on a common volume control, were all used for reproducing the orchestra. For the solo passages of "Götterdämerung," Miss Davis as Brünhilde sang into a special microphone which picked up her voice but very little of the orchestra music, and the center channel was then used with a separate volume control to reproduce her voice in such a way that it always dominated the orchestra. Mr. Stokowski had before him the volume controls, a set of quality controls by means of which he could increase or decrease bass or overtones at will, a microphone through which he could talk to the orchestra, when they were not playing, and a signal system for communication with Mr. Smallens during the renditions. By means of this microphone circuit the orchestra in Philadelphia could also hear the hearty applause of the Washington audience and were given a direct indication of the appreciation of their efforts. The details of the complex line circuits supplying these arrangements are presented by Mr. H. S. Hamilton in Part II of this paper.

LOUD SPEAKER ARRANGEMENT



Dr. W. W. Campbell, President of the National Academy of Sciences, introduced Dr. Harvey Fletcher, Director of Acoustical Research at Bell Telephone Laboratories. With the assistance of engineers and members of the orchestra in Philadelphia, Dr. Fletcher then performed several experiments to demonstrate the important characteristics of the new apparatus. The first set of experiments demonstrated auditory perspective. On a small stage at the Academy of Music in Philadelphia, where the pickup microphones were installed, a workman busily constructing a box with hammer and saw was receiving suggestions and comments from a fellow workman in the right wing. All the speech and accompanying sounds were transmitted over cable circuits to the loud speakers on the stage of Constitution Hall in Washington. So realistic was the effect that to the audience the act seemed to be taking place on the stage before them. Not only were the sounds of sawing, hammering and talking faithfully reproduced, but the correct auditory perspective enabled the listeners to place each sound in its proper position, and to follow the movements of the actors by their footsteps and voices.

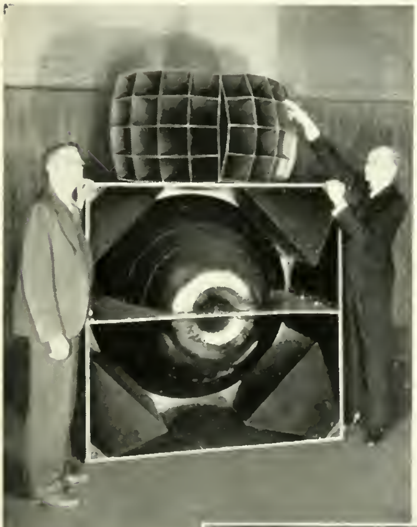
For another demonstration, the audience heard a soprano sing "Coming Through the Rye" as she walked back and forth on the stage in Philadelphia. Here again her voice was reproduced in Washington with such exact auditory perspective that the singer appeared to be strolling on the stage of Constitution Hall.

In one experiment a trumpeter in Washington and one in Philadelphia played alternately at stage center, and then walked to opposite sides of the stage to play a duet. Spot lights assured the audience that only one trumpeter was present in Washington, though without lights they could not have told which was which. The music of the Washington trumpeter constituted the only sounds heard from the stage which did not originate in Philadelphia. In still another demonstration sounds of a bell and tambourine flitted about the stage, high overhead as well as from side to side.

To show the volume range possible with the new equipment, the orchestra played a selection at a constant level of loudness, while the output of the loud speakers was varied from a level so low that the instruments could scarcely be heard, up to a loudness almost great enough to be painful. Throughout the whole range, the reproduction was faithful in all respects except the level of loudness; there was no appreciable distortion or noise to mar the perfection of the reproduction, and the wide range in volume was vividly impressed on the audience.

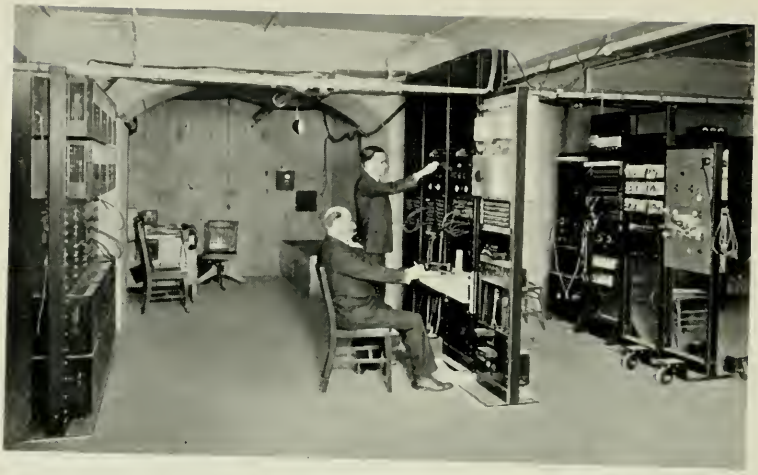
The effect of limiting the range in pitch, or frequency, was illustrated by employing electric filters to cut out one octave at a time—first from the upper end of the range and then from the lower. The new apparatus reproduces faithfully about 9 octaves or from 40 to 15,000 cycles, compared to about six for ordinary radio reproduction. As a preliminary experiment an oscillator in Philadelphia transmitted over the line and through the system frequencies continuously varying from

(Right) R. J. Tillman of the American Telephone and Telegraph Company, Left, and A. R. Soffel of Bell Telephone Laboratories, Right, at the Voltage Amplifiers in Constitution Hall, Washington, D. C.



(Left) E. C. Wente, Left, and A. L. Thuras, Right, of Bell Telephone Laboratories, Discussing the Distribution Obtained from the High Frequency Loud Speakers Used for the Frequency Range 300 to 15,000 Cycles. Lower frequencies were radiated by the large unit on the floor.

(Right) Control Equipment Used by Mr. Stokowski; on the Right the Quality Control, Volume Control Center, and Switching Box at Left. The right hand dial controlled the orchestra channels, the left hand the solo channel when used. The first two keys at right of switching box were the tempo signal and orchestra stop-play signal respectively. Communication with the orchestra was obtained through the microphone on the volume control box.



(Above) THE CONTROL ROOM IN THE BASEMENT OF THE PHILADELPHIA ACADEMY OF MUSIC. W. A. Munson of the Bell Telephone Laboratories measuring power level sent to Washington and R. L. Snyder of the Bell Telephone Company of Pennsylvania talking on the order wire. At the left are the power amplifiers and at the right switching apparatus used in the demonstrations.

(Right) D. T. BELL OF BELL TELEPHONE LABORATORIES, AT THE POWER AMPLIFIERS IN CONSTITUTION HALL, WASHINGTON, D. C.

40 cycles to 15,000 cycles. The frequency of the tone was indicated by a line moving across a large chart showing a musical scale extended to accommodate this wide range. Then the effects of eliminating high and low frequencies from both a fife and drum duet and from the music of the orchestra were presented. By this demonstration the audience had the opportunity of judging the importance of the complete range to the full aesthetic appeal of music, and of comparing it with the more limited ranges ordinarily heard with other methods of reproduction.

The technical features of these new developments, which were carried on as part of the research program of the American Telephone and Telegraph Company, were disclosed for the first time by Dr. F. B. Jewett, Vice President of the American Telephone and Telegraph Company in charge of development and research, at a meeting of the National Academy of Sciences on Tuesday afternoon of April 25th. In discussing the future of the new system, Dr. Jewett said in part:

"As to the future of the accomplishment shown here today, it is difficult to make any definite prediction. What we have done is to produce pickup microphones, amplifiers, electrical filters, transmission lines and loud-speaking reproducers so perfect that the entire frequency and volume range of the most exacting orchestral and vocal music can be reproduced at a distance without impairment of quality. We have also worked out the arrangements by which substantially perfect auditory perspective is possible. This latter is an essential part of the problem if realistic illusion as to the physical arrangement of the component parts of an orchestra is desired.

"We can place at the disposal of the musical director instrumentalities which will enable him to produce at a distant point, or at many distant points simultaneously, a completely faithful replica of the tonal effects produced locally in the auditorium on the stage of which the orchestra is performing. Likewise, portions of this same equipment place at his disposal the means of very greatly extending the range of orchestral reproduction and of making possible artistic effects hitherto unattainable.

"With these instrumentalities available, the questions of the manner and extent of their use are primarily questions for the musician and those interested in music rather than for the physicist and the engineer. Our job has been to produce a set of tools. The musicians and musical directors, and back of them the musical composers, must determine just how these tools can best be used and what they can best produce. By its very nature the ensemble of what we have created is primarily of value for musical production or reproduction in halls, theatres or auditoriums. In a word, its field of applicability is where a large number of people might congregate for the common enjoyment of music of distinction. In its present form it is not directly applicable to the limited environment of the home.

"These new tools offer not only an enlarged field of possibility to the musician and the composer for the production of auditory effects, but likewise a great broadening of the audience which derives pleasure from such effects. Many people, especially in our smaller cities, are now deprived of the ability to hear good orchestral music by the factors of cost and distance, and the element of time in going to the cities where orchestral music is normally produced. What we as physicists and engineers have done is to provide a mechanism for obviating these factors. Whether the results justify our expections is for others to say."

W. B. Snow

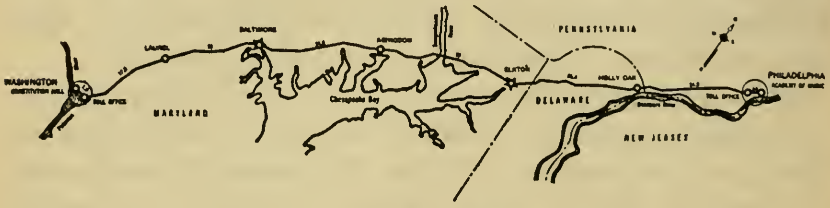
Part II. Transmission

The transmission of orchestral music to distant points for reproduction with the perfection described by Mr. Snow in Part I of this article requires that the transmission channels be of such a character as not to limit the performance of the new reproducing system either in frequency range or volume range, or by the introduction of other forms of distortion. High grade circuits for the transmission of music are not, of course, new in the Bell System. Our better grade program circuits are capable of transmitting a frequency band from 40 to 8,000 cycles and a volume range of the order of 45 db for a length of 1,000 miles, which volume range corresponds to a power ratio of 25,000 to 1. This performance is more than adequate for present day chain broadcasting. The new circuits must, however, transmit a frequency band nearly twice as wide and a volume range more than 30 db greater than for the 1,000-mile program circuit. This greater volume range represents an increase in power ratio several thousand fold.

Although transmission at audio and carrier frequencies were both considered in the preliminary studies, the interference and distortion requirements as well as the general trend of recent development, indicated that carrier transmission was preferable, at least over the major part of the path. Non-loaded program pairs were available in one of the cables between Philadelphia and Washington. In this cable as well as in the other cables on this route carrier was not used. By employing carrier for the new channels, therefore, there would be no cross-talk interference from other pairs in the cable, since the lowest carrier frequency would be above the highest audio-frequency.

The choice of carrier, and the particular value of carrier frequency selected, were also influenced by a survey of the sources of outside interference which might affect the quietness of the circuits between the terminal cities. Several such sources were found, but the highest had a frequency of 22,000 cycles. By choosing a carrier of 40,000 cycles, therefore, and transmitting the lower side band, 25,000 to 40,000 cycles, outside interference could be minimized. Because facilities for the operation of carrier apparatus, such as adequate power supplies, were available at the toll offices in Philadelphia and Washington, the carrier channels were terminated at these two points. Between the toll offices in the two cities and the Academy of Music in Philadelphia and Constitution Hall in Washington, audio-frequency transmission was employed. These distances were short enough so that neither crosstalk nor noise arising in them was of much consequence.

The actual route of the cable is shown in the accompanying illustration. Regular telephone repeater stations are located at Philadelphia, Elkton, Baltimore and Washington. Because of the large attenuation at the high carrier frequencies, however, three additional intermediate amplifier stations were established at Holly Oak, Abingdon and Laurel. At Holly Oak the amplifiers were housed in an existing telephone office, but at Abingdon and Laurel small temporary structures were erected which were just large enough to house the equipment and to permit an attendant to be stationed there during the demonstration. The structure at Abingdon was of welded steel and is shown in Figures 1 and 2.



CABLE ROUTE PHILADELPHIA - WASHINGTON

All of the carrier amplifiers, both at the two terminals and at the intermediate stations, were especially designed both to be unusually free from distortion or non-linearity, and to be very stable with respect to variations in power supply. Except at the Philadelphia terminal, equalizers, associated with all the amplifiers, were employed to compensate for the difference in attenuation at the various frequencies, so that the output of the amplifiers would be at the same level for all frequencies. Although the gain introduced at each amplifier station at the higher frequencies was about 50 db, correspond-

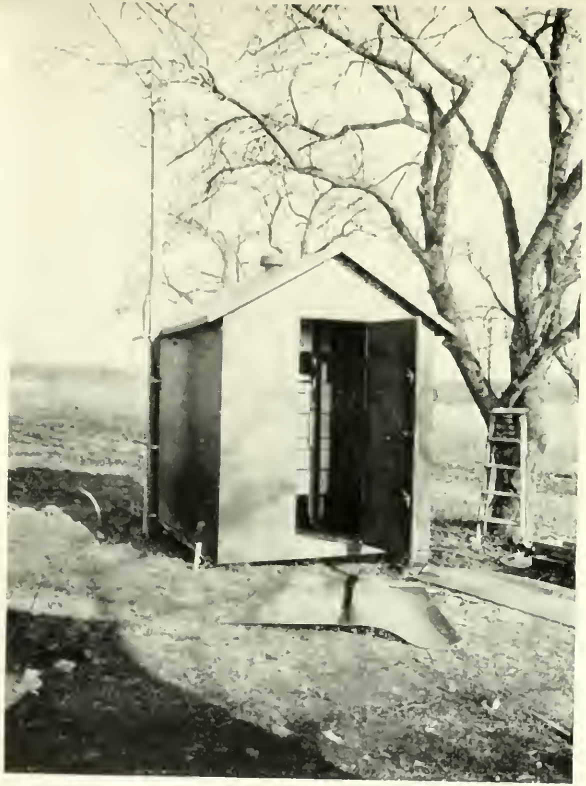


Figure 1. The Temporary Amplifier Station at Abingdon Was a Small Welded Steel Structure of Inexpensive Yet Rugged Construction.

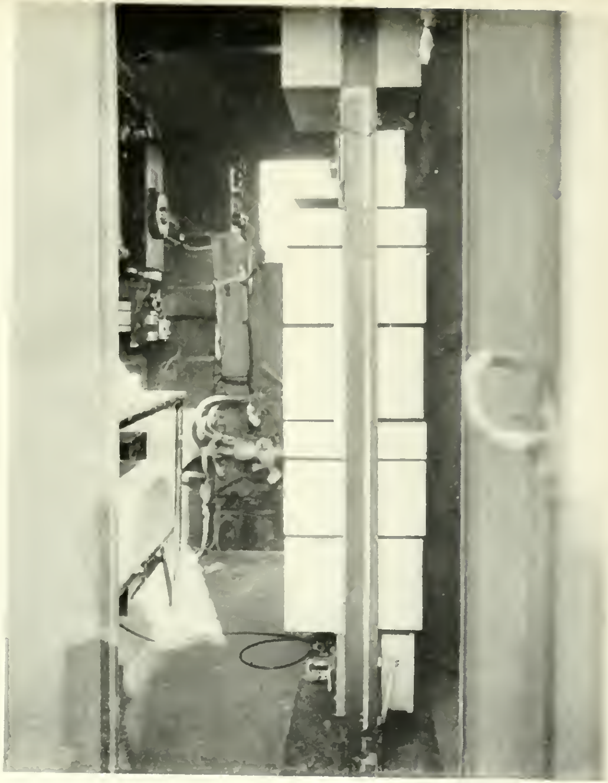


Figure 2. Within the Abingdon Amplifier Station Was a Single Bay Carrying the Amplifiers, Equalizers, and Accessory Equipment and Maintenance Facilities to Permit Emergency Repairs and Adjustments.

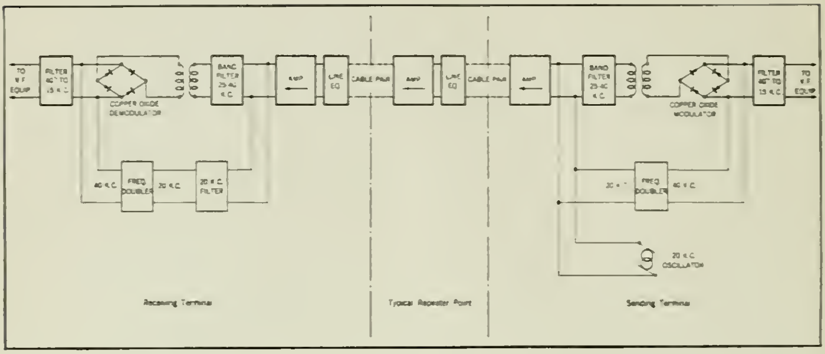


Figure 3. Simplified Schematic of a Single Channel for the Philadelphia-Washington Demonstration.

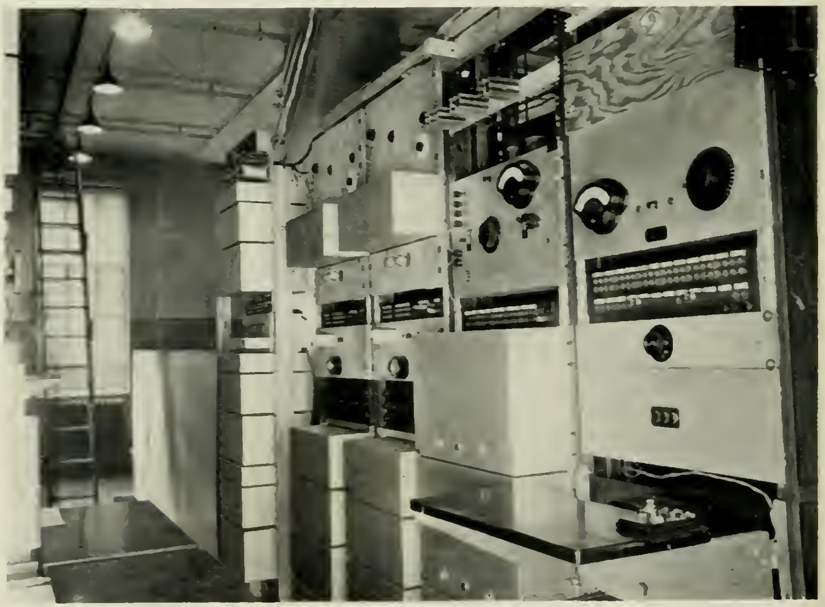


Figure 4. Toll Terminal Equipment at Washington.

ing to a power amplification of 100,000 times, the overall characteristic of the lines—from the Academy of Music to Constitution Hall—was flat to within ± 1 db over the entire frequency range from 40 to 15,000 cycles. Due to the employment of very stable amplifiers and underground cables which were not subject to rapid changes in temperature, the transmission variation over the entire frequency band did not vary more than a few tenths of a db from day to day.

Amplifiers and equalizers are required for the short audio-frequency circuits at each end, as well as for the carrier circuits. Existing apparatus was employed, although modified slightly to meet the unusual conditions of the Philadelphia-Washington demonstration. At Philadelphia both amplifier and equalizer for the audio-section were located in the Philadelphia toll office, but in Washington, the amplifier was at the toll office, and the equalizer in Constitution Hall.

The carrier system employed differed from those ordinarily used in that it incorporated "vestigial" side band transmission. In carrier systems for ordinary speech transmission, the transmitted band extends approximately from 200 to 2,700 cycles. If a carrier of 40,000 cycles were to be used for voice transmission, and the lower side band transmitted, the voice frequencies would be allowed to modulate the carrier and thereby produce the usual sum and difference frequencies. There would thus result a band of frequencies from 37,300 to 39,800 cycles and another from 40,200 to 42,700 cycles. The separation of 400 cycles between the highest frequency of the lower side band and the lowest frequency of the upper side band is sufficient to allow the filters to introduce enough loss so that practically none of the upper side band is transmitted. The carrier is substantially balanced out in the modulator.

For the Philadelphia-Washington demonstration, however, the frequency band was from 40 to 15,000 cycles, and as a result the lower side band extended from 25,000 to 39,960 cycles. Between this highest frequency of the lower side band

and the lowest frequency of the upper side band is a band of only 80 cycles. The provision of a filter which would have the necessary discrimination in this narrow band against the unwanted side band presented a rather severe filter design problem. Instead of attempting to provide a filter of that kind, a filter of considerably less sharp discrimination was employed which allowed some of the unwanted (upper) side band to pass. By careful attention to phase relations between the wanted side band and the portion of the unwanted side band that was transmitted the combined result at the receiving end was the same as if the entire lower side band was transmitted without any of the upper.

This type of transmission requires very accurate control of the phase relationship between the carrier frequency supplied to the modulator at the sending end and that supplied to the demodulator at the receiving end. This was accomplished by transmitting a special control frequency of 20,000 cycles over each circuit along with the music band. At each end of the line frequency doublers are employed to obtain 40,000 cycles for modulating and demodulating. The general arrangement of the carrier portion of the circuit is shown in Figure 3.

As already noted, one of the most difficult requirements to be met was the wide volume range that had to be transmitted. In general, the volume range a system can transmit is limited by the maximum power the amplifiers can handle without distortion, and the minimum level to which the signals may be allowed to drop without being interfered with by noise. This noise may be introduced either through the cable sheath from outside sources, or from other conductors within the cable. One of the advantages of using the higher carrier frequencies is that the sheath of the cable acts as a more effective shield. Because of this fact, and of the placement of the frequency band already discussed, no special precautions had to be taken to decrease outside interference.

The situation regarding noise introduced from other pairs in the same cable was not quite so satisfactory. There was, however, no appreciable source of noise at any point except Baltimore. Here the level of the incoming signals was so low that certain high frequency noises produced in the office, entered the cable on the other pairs and caused interference. To eliminate this, choke coils were introduced in all pairs of the cable but those used for the music transmission. These coils were not inductive to ordinary telephone and telegraph currents but were inductive to currents flowing over the conductors to ground, thus reducing these currents and minimizing their interference with the music.

To assist further in transmitting the desired volume range, the method of predistortion was resorted to. In music the energy content of the higher frequencies is materially less than that of the lower, so that if they were sent out over the line at their true levels, line attenuation would much sooner reduce them to levels where noise interference becomes of importance. By increasing the level of the frequencies above 1,000 cycles relative to the frequencies below 1,000 cycles, however, this is avoided, and no overloading of the amplifiers results because after the higher frequencies have been increased, they still have no greater energy content than the lower. At the receiving end the proper amplitude relationship between high and low frequencies is restored by networks which decrease the levels of the higher frequencies by the same amount they were increased by the predistortion. By these various means a volume range of the order of 80 db is realized without either overloading the amplifiers or introducing noise.

As discussed in the accompanying paper referred to, three separate channels were employed for the demonstration, and for these channels three non-loaded program pairs of one cable were used. Three additional non-loaded pairs were provided as spares, and were arranged so they could be patched in at any repeater station in place of the regular pairs. Two additional transmission channels were set up which were in a different cable all the way from Philadelphia to Washington. These two circuits were taken from the regular program circuit layout and were operated on an audio-frequency basis throughout. Minor readjustments were made on these circuits so that for the moderate distance involved they would transmit a frequency range from 40 to 9,000 cycles and a volume range of about 60 db. At the two terminals they were arranged through switching devices so that either or both could be instantly substituted for the channels they were designed to protect. Had it been necessary to utilize these emergency channels, a very creditable performance could have been given although some slight impairment might have been detected.

In addition to these main and emergency circuits for transmitting the music, others were set up for signaling and supervisory purposes. A talking circuit was extended from a microphone in the control box at Constitution Hall to a loudspeaker on the stage of the Academy of Music so that Mr. Stokowski at Washington could talk to Associate Conductor Smallens at Philadelphia. This circuit was also connected to loudspeakers in the control rooms at the two terminals to enable the operators to follow more easily the continuity of the performance. Two signal circuits under the control of Mr. Stokowski were also established between the same points. Over one he signaled to start and stop the orchestra, and this circuit was associated with a switching mechanism which cut out the loudspeaker at the Academy of Music when the orchestra was playing. This was necessary to avoid "singing" around the circuit consisting of the main channels and the "Stokowski" talking channel. The other circuit was to signal the tempo for various passages in each selection. This was necessary because the talking circuit was interrupted while the orchestra was playing.

Besides these various signaling and talking circuits, two order wire circuits were provided. One enabled the men at all repeater points to be in communication with the control office in Washington, and the other served as a communication channel between the operators at Constitution Hall and the Academy of Music.

The terminal equipment at Washington was set up on six bays. The installation is shown in Figure 4. At the extreme left is the bay containing the carrier amplifiers and their associated equalizers for the three line circuits. The carrier terminal equipment, consisting of demodulators, band pass filters, etc., is mounted one bay per channel. Two bays are shown in the photograph, the third bay being temporarily located at Philadelphia when the photograph was taken. The two bays in the foreground include amplifiers, jacks, volume indicators, and other equipment associated with the audio-frequency portion of the lines.

The severe requirements for this new type of service not only necessitated the most careful design of all the component parts, but required many weeks of testing before the final demonstration. For one series of tests a circuit was set up from Philadelphia to Baltimore and back over which music was transmitted from the stage in the Academy of Music to loudspeakers set up in the foyer. The reproduction of music transmitted both over this 200-mile loop and over an equivalent distortionless network was then listened to successively. No difference in quality was detectable. Although a considerable amount of time was spent in developing and perfecting the apparatus and arrangements for this first demonstration, the designs made and experience gained will greatly facilitate the establishment of similar circuits elsewhere as occasion warrants.

H. S. Hamilton

The Talking Efficiency of Telephone Circuits

WHEN in 1876, Dom Pedro, Emperor of Brazil, attracted by his friendship for Alexander Graham Bell to a modest exhibit at the Centennial Exposition, placed the crude model of Bell's electrical speaking telegraph to his ear, he uttered that historic exclamation, "My God! It talks!" His amazement was not clouded by any question of quantitative measurement of this marvelous phenomenon, of expressing by some number just how well the instrument talked, nor of determining how its performance could be measured or computed. It was sufficient that this little scientific toy actually reproduced the human voice.

This is typical of the first stage in the development of a new application of science. But when the marvel that it works at all becomes a commonplace, and the invention passes from the stage of a scientific toy into that of commercial application, there quickly develops a desire to measure and to express its performance in quantitative terms. Very soon the question is asked, "How well does the device perform in this case and in that?" As efforts are concentrated on improvements so that the new device may give better service to the customers, the need becomes constantly more apparent for methods of quantitative measurements to express as accurately as possible the degree of satisfaction given to the customer. Standards of performance to be met under various conditions are established and the actual performance of the product is compared with these standards. The degree of improvement in performance resulting from further perfections is expressed quantitatively and the way is laid for comparing the relative performance and costs resulting from different designs or methods.

Sometimes this measurement of performance is very complicated. How, for example, can one express in terms of a single figure the technical performance of a motor car? In the past, much weight was often given to the miles per gallon of gasoline; but how many today buy cars on that basis? Apart from questions of economy, a comprehensive measurement of performance must take into consideration acceleration and braking, speed, riding qualities, turning radius, ease of control, and freedom from breakdowns or repairs. Also the variation in these qualities with the age of the car is a factor.

Electrical Efficiency Used to Measure Transmission

When methods for the quantitative measurement of the relative talking efficiencies of telephone circuits were first being developed, circuits were compared on the basis of the loudness of the sounds received over them. It is true that even then there were other factors influencing the talking efficiency. However, methods were lacking for measuring these influences in the early days, and in fact the loudness of received sounds was by far the most important factor in comparing the relative performance of different circuits. It was natural then that the first quantitative comparisons were made by selecting a typical telephone circuit as a standard and adjusting the length of circuit until it gave the same loudness as the circuit under test. This led to the first quantitative scale, the number of miles of cable in the standard circuit, when so adjusted, being used as a measure of the talking efficiency of the circuit under test. At first this comparison was made by ear. Those who are familiar with the technique of telephony realize that this was a laborious and rather unprecise method of comparison.

Many readers also realize the difficulties which lay in the way of the development of more precise methods, either of computation or of measurement, because of the nature of telephone currents and the characteristics of telephone circuits. The currents which transmit conversations over telephone circuits consist of groups of complicated electrical oscillations, each group, in general, representing a syllable, the groups following each other in rapid succession along the circuit. This is illustrated by the oscillogram shown in Figure 1. On the average, the syllables are approximately 0.2 second in length. While at first glance, these oscillations seem to be quite transient in character, if certain parts are repeated on a more rapidly moving film, as in Figure 2, it is seen that they are periodic in character. Generally speaking this applies to the vowels, which are sustained long enough to have this periodic character, while the consonant sounds are short and transient.

The direct application of exact mathematical analysis to the propagation of these complicated groups of oscillations over long and complex telephone circuits, and to the acoustic-electric transformations in the telephone transmitter and receiver, is impracticable. As is the case in many types of practical problems, the physical processes involved are far too complicated to be handled in this way. However, the telephone transmission problem lends itself to indirect mathematical treatment of great practical value. The complicated oscillations can be considered as formed by the combination of a large number of simple single frequency currents. The mathematical treatment of the transmission over telephone circuits of these single frequency components had not been developed in the early days of telephony, but has now been developed to a high point.

The analysis by experimental methods of the telephone currents shows that, while theoretically their single frequency components cover a very wide range of frequencies, the most important part of this range is between 300 and 2,700 cycles. A study of the transmission of single frequency components throughout this range gives then a means of determining the quality of transmission of the telephone currents. Fortunately for many types of case the relative loudness of sounds reproduced from telephone currents can be determined by studying the efficiency of transmission of one single frequency com-

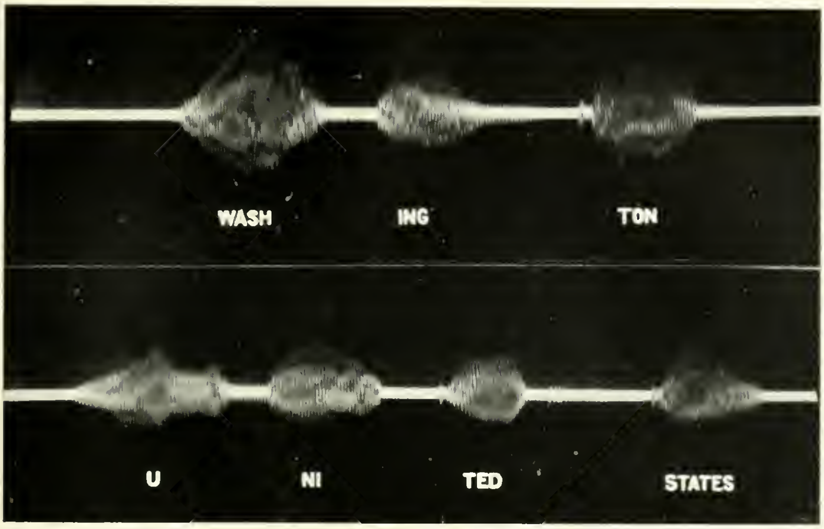


Figure 1. Oscillogram Showing the Telephone Currents Produced When the Words "Washington, United States" Are Spoken into the Telephone Transmitter. These currents consist of groups of complicated oscillations, each group in general representing a syllable.

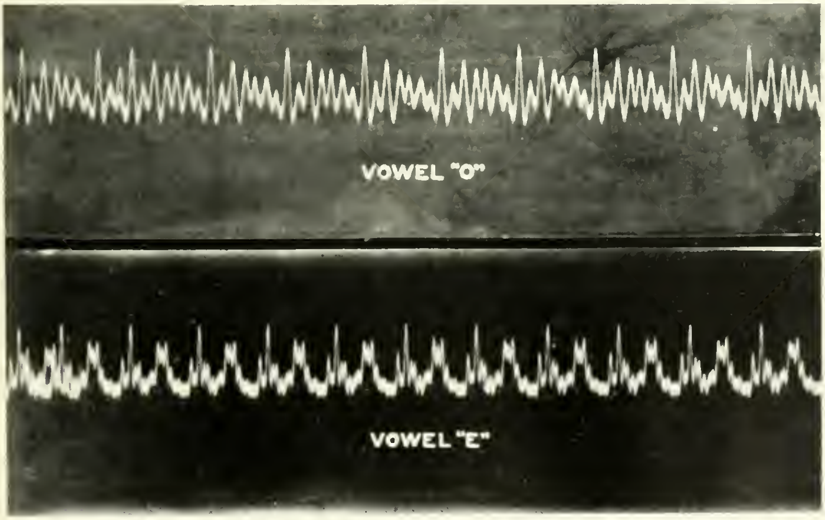


Figure 2. Oscillogram Showing in Detail the Telephone Currents Produced When the Vowels "O" and "E" Are Spoken into the Telephone Transmitter. The speed of the film was about ten times that of figure 1. These currents are periodic in character.

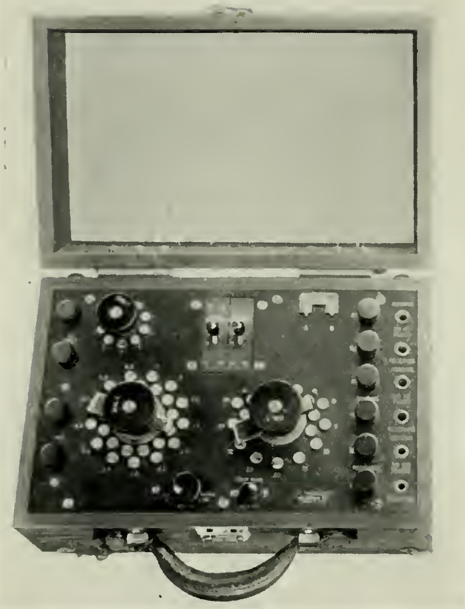


Figure 3. Early Type of Transmission Measuring Set Using 1000 Cycle Current with Ear Balance Measurements.

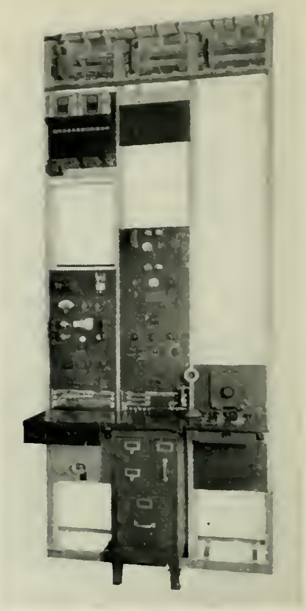


Figure 5. Modern Transmission Testboard for Use in Toll Offices, Showing the Transmission Measuring Set in the Lower Left Panel, the Associated Oscillator and Amplifier in the Center Panel and an Impedance Bridge in the Lower Right Panel.

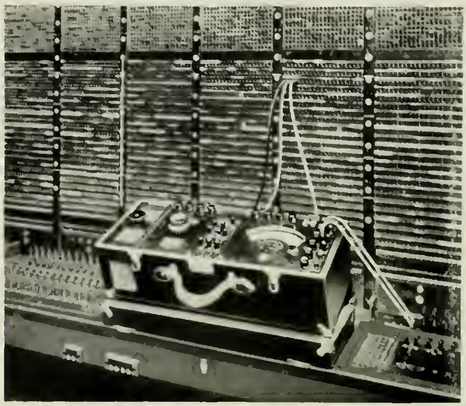


Figure 4. Portable Measuring Set Employing an Amplifier and Meter, Showing the Set in Use for Testing Switchboard Circuits.

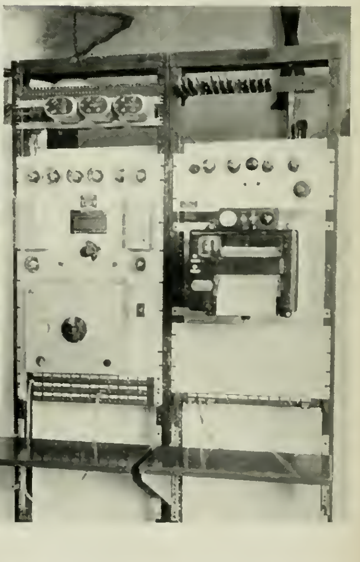


Figure 6. Experimental Model of Automatic Recording Transmission Measuring Set Arranged to Produce a Graphical Record of Transmission Efficiency as a Function of Frequency or of Time.

SEVERAL TYPES OF TRANSMISSION MEASURING SETS ponent, thus greatly simplifying a very complex problem. The frequency used for this purpose is 1,000 cycles.

Although the theory of transmission of single frequency currents, as applying to telephone circuits, has now been highly developed, it would be quite out of the question to make a precise computation in each case of the efficiency for even one frequency, such as thousand cycles. For practical telephone work it has been necessary to develop methods of approximation and simplification and to prepare by these methods tables and curves from which an approximate answer can be quickly obtained in practical cases. The overall efficiency of the electrical part of a telephone circuit is often in the order of one per cent or a fraction of one per cent, that is, 1/100 or less of the transmitted power is delivered at the receiving end, and the approximate methods in current use enable this efficiency to be quickly estimated with a precision sufficient for usual engineering work.

Methods must be available not only for computing the talking efficiency of telephone circuits, but also for measuring it. Here again the electrical efficiency of transmission of a single frequency component can be used as a practical approximation to the talking efficiency as long as the loudness of received sounds is the criterion. However, conditions for this measurement are so different from those of ordinary alternating current measurements that the methods used for power circuits cannot be applied to telephone circuits. The telephone currents at the transmitting end of a circuit do not exceed one or two milliamperes in amplitude and at the receiving end are often only a few microamperes. Measurements on telephone circuits must, in general, be made with currents of magnitudes and frequencies comparable to those of currents transmitting conversations because the efficiencies vary with both the magnitude and the frequency of the currents. When measurements first became generally important, the problem was so to design telephone transmission measuring equipment that a measurement which at that time was a delicate laboratory operation could be made on a large scale by plant men without special training as a part of their routine job.

This has been accomplished with a high degree of success. In the earliest transmission measuring sets, as indicated in Figure 3, the comparison was by ear, thousand cycle alternating current being transmitted alternately through the testing apparatus and over a circuit which looped back to the sending point, and the current received through the testing apparatus adjusted to be of equal loudness to that received over the circuit. With the development of amplifiers, however, it became practicable to show the received current on a meter. An early type of this kind of apparatus, portable in character, is shown in Figure 4. Figure 5 shows a modern transmission testboard for use in large toll offices. An interesting further development which has been made experimentally is an automatic recording measuring set (Figure 6) by means of which within a minute a record is made of the transmission efficiency of a circuit over the entire range of telephone frequencies.

So far the discussion has related principally to the electrical part of the circuit. However, the overall efficiency of a telephone circuit depends also on the efficiency of conversion from acoustic to electric oscillations in the transmitter and from electric to acoustic oscillations in the receiver. In the early standard of reference in which efficiencies were judged by comparing the loudness of transmission with that over a typical circuit, this factor was, of course, included although in a rather crude way. Standards of comparison for these acoustic-electric conversions have since been established both for the transmitter and for the receiver and these, combined with means for adjusting the circuit efficiency as desired between the standard transmitter and receiver, give a complete standard reference system. The system which was adopted as standard is an idealized system giving nearly perfect reproduction of sounds between transmitting and receiving ends. The assembly of apparatus involved is indicated in Figure 7.

Other Factors Affecting Talking Efficiency

In the ways described above, a very complete technique has been developed for both computation and measurement of the electrical efficiency of telephone circuits and for expressing this efficiency in terms of transmission units in a standard reference circuit adjusted to the same overall efficiency. However, while this method of rating telephone circuits was being perfected, it even then was becoming little by little less adequate. The purpose of the telephone circuit is not fundamentally the transfer of electrical energy from one point to another, but it is the transfer of information. The power efficiency is of interest because it represents the loudness of reproduced sounds, and this in turn is one of the important factors determining the ease with which the transfer of information is made, that is, it affects the talking efficiency of the circuit. But from an early day, other factors appeared in the problem, and they rapidly became of increasing importance.

These factors include the other noises heard by the man listening to the telephone conversation—noises present in the room where he is listening and noises produced in the receiver by currents arising from induction from other electrical systems. If noise from any of these sources is great, the received conversation obviously must be louder than otherwise would be required. The loudness of room noises varies over a surprising range from place to place. This is indicated by Figure 8. The reader will note that the energy level of noise varies over a range of one million to one as between very noisy and very quiet locations.

A second factor is the variation in the efficiency of transmission of the different components of the telephone currents. Such variations have always been present in telephone circuits, but in the early days the circuits were sufficiently similar in their characteristics to make this factor unimportant for their comparison. But transmission over longer and longer distances was based on the use of new types of telephone circuit, particularly loaded circuits, markedly different in their characteristics from the non-loaded circuits which had preceded them. Fig-

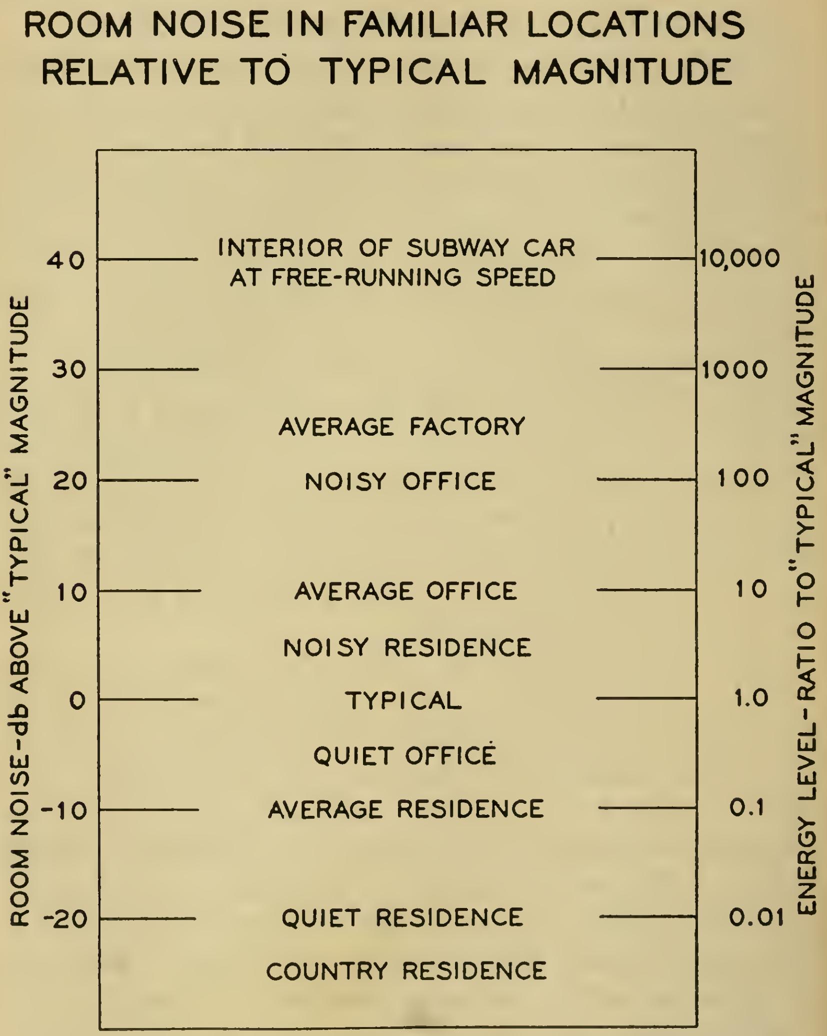


Figure 8. The Range of Loudness of Room Noise in Familiar Locations.

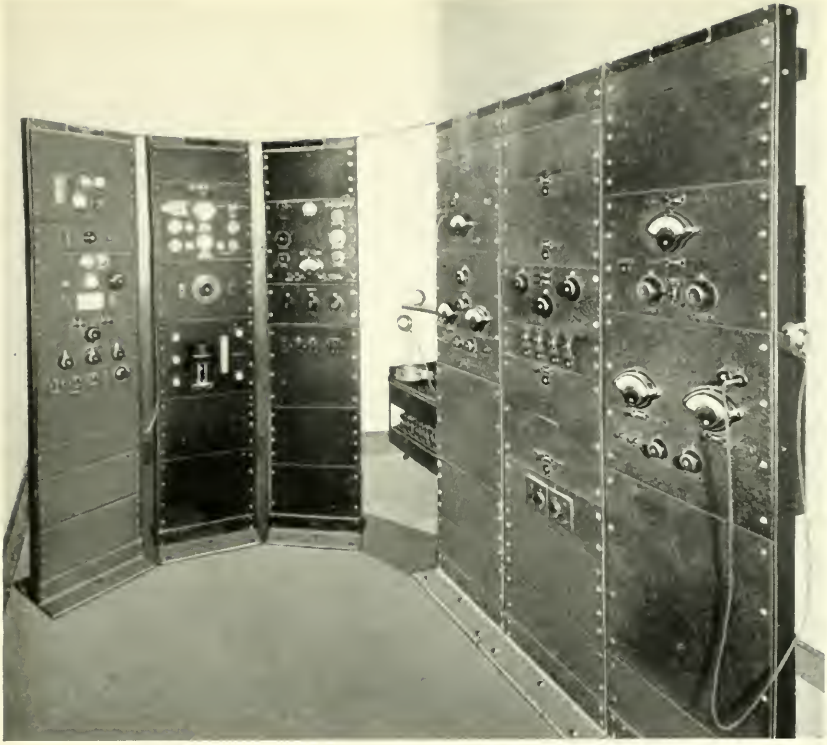


FIGURE 7. ASSEMBLY OF MASTER REFERENCE SYSTEM FOR TELEPHONE TRANSMISSION WITH ASSOCIATED CALIBRATION APPARATUS. The transmitter, line and receiver are shown at the right, and the calibration apparatus at the left.

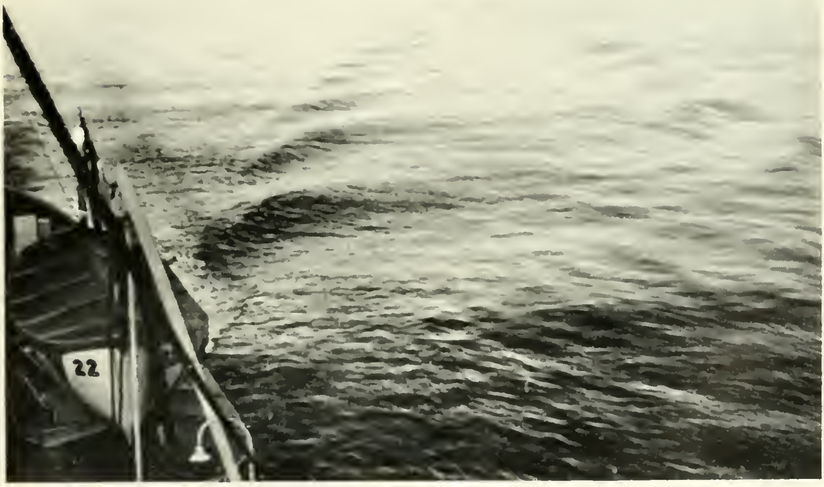


FIGURE 10. DISTORTION OF THE SHAPE OF WATER WAVES RESULTING FROM THE VARIATION IN THE VELOCITY OF TRANSMISSION OF THE DIFFERENT FREQUENCY COMPONENTS.

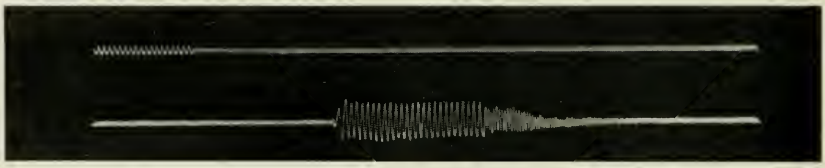


Figure 11. Oscillograph Showing the Distortion of Electrical Waves in Telephone Circuits Resulting from Differences in the Velocity of Propagation at Different Frequencies. The upper curve shows a compound wave consisting of 800 cycles and 1,600 cycles at the transmitting end of a 600-mile medium heavy loaded repeatered cable circuit. The lower curve shows the received wave after amplification, the distortion resulting in the 800-cycle component being received first, followed by the 1,600-cycle component.

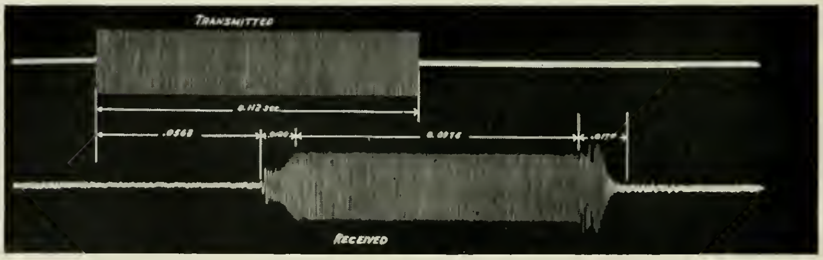


Figure 12. Distortion of the Electrical Waves in Telephone Circuits Resulting from Transient Effects. The oscillograph of the transmitted and received waves for a 1,600-cycle impulse sent over a 522-mile medium heavy loaded repeatered circuit shows the gradual building up and dying out of the received wave.

ure 9, for example, shows the electrical efficiency at various frequencies in the telephone range of three types of telephone circuit in cable: first, 8½ miles of non-loaded 19 gauge cable representing the early art; second, 100 miles of heavily loaded 19 gauge cable representing the long distance art of 20 years ago; and third, 1,000 miles of lightly loaded 19 gauge cable representing the art of today. The modern 1,000 mile circuit has a better characteristic than either of its shorter predecessors. Another cause of difference in frequency characteristics is the difference between the various types of telephone instruments in use. An instrument which has a wide variation in efficiency of acoustic-electric conversion over the range of

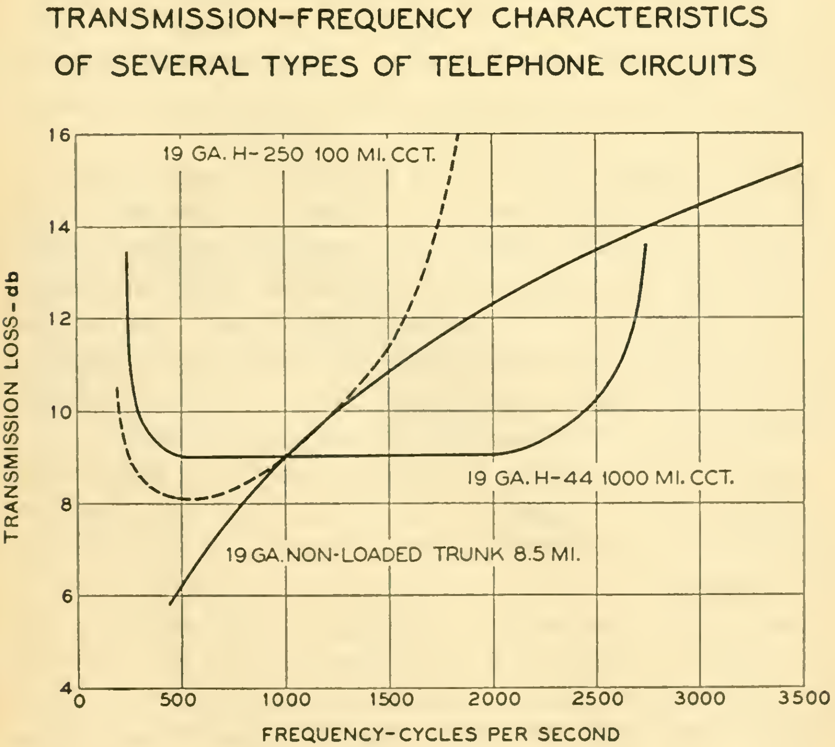


Figure 9. Electrical Efficiency at Various Frequencies of Three Types of Telephone Circuits. The modern 1,000-mile circuit has much better characteristics than either of the shorter earlier types shown.

telephone frequencies gives, for an equal loudness, materially less clear conversations than an instrument having a flatter characteristic.

Still another important factor is the effect of "sidetone"; that is, the reproduction in the telephone receiver of the voice of one speaking in the transmitter of the same set and of room noise picked up by this transmitter. The loudness of sidetone varies materially under different conditions, with a corresponding variation in the effect on telephone transmission. With a large amount of sidetone, a person tends to talk at a lower volume level because hearing his own words loudly repeated in his ear gives him a sensation of speaking loudly. This results in a lower received volume than would be the case if the talker had no sidetone. Also, the loudness of sidetone partly determines the extent to which room noises reach the ear of the listener and hence the extent to which they tend to mask or interfere with the reception of the conversation.

Without discussing in detail all of the considerations involved, these illustrations are sufficient to show that in determining the talking efficiency of circuits it quickly became necessary to take into account many other things in addition to power efficiency. As these factors developed in importance, and as quantitative information about them became available, this has been done to an increasing extent, until the entire base for the rating of telephone circuits has been changed.

How can one express in quantitative terms this overall characteristic of a telephone circuit which we have been describing? Consideration has been given to various methods, including the use of "articulation tests" by which are determined the percentages of syllables from selected lists that are correctly transmitted over the circuit under test conditions. The method now used as the basic criterion, however, bears more directly upon the results obtained under actual service conditions. It makes use of the frequency with which repetitions occur in actual conversations. This has been determined for commercial conditions by observing conversations between telephone employees using tie trunks between various parts of the telephone organization. The characteristics of these tie trunks have been modified from time to time to represent various conditions of noise, distortion, volume efficiency and sidetone, and the effect on the number of repetitions noted. Two circuits are said to have the same talking efficiency when their repetition rates are the same for the same service. Taking one form of circuit as a basis of reference, the talking efficiency is expressed in terms of the volume efficiency of this circuit when adjusted to give the same repetition rate.

Effect of Time of Propagation

The development of telephony over very great distances, and, subsequently, the use of cable circuits for distances running up to 2,000 miles or more, have made important an additional group of phenomena of great interest, resulting from the time required for the propagation of the telephone currents over the circuits. These all enter into the talking efficiency of the circuits. At the present time sufficient information is not available to enable these effects to be rated quantitatively in terms of the volume efficiency of a reference circuit, but they are limited to specified maximum values in the design of the circuits. A brief review of them is necessary for an all-around consideration of the talking efficiency of telephone circuits.

There appears to be a surprising adaptation of the characteristics of things in this world to the purposes to which they are put by man. Perhaps it would be more accurate to say there is a surprising adaptation of man to make effective use of the materials at hand. Be that as it may, one can but marvel at the way in which the characteristics of iron, of copper, of wood, of water and of air, not to mention a thousand other substances, lend themselves to the complicated organization of machinery and of structures which form the skeleton of our industrial society, and even more important, how certain of these materials and the conditions of temperature and climate which surround the earth, lend themselves to the maintenance of that most complicated organization, life. Similarly, there appear to have been provided just the right conditions for universal electrical communication in this world. If communication were dependent upon acoustic methods, telephone conversations over long distances would naturally be out of the question. The time of propagation, for example, between New York and Chicago would be more than one hour, and an equal time would be required for the transmission of each response. However, the maximum velocity of propagation of electromagnetic waves, 186,000 miles a second, is such as to make possible transmission between any two points on the earth's surface in about 1/15 of a second, a time delay small enough to be satisfactory for conversations.

This maximum velocity of propagation of electromagnetic waves is by no means the velocity of propagation over all types of telephone circuit. Early types of loaded cable circuit had a velocity of about 8,000 miles a second. While suitable for moderate distances, this would cause trouble for such distances as separate remote parts of our own country. However, the development of long distance transmission through cables required, for other reasons, the development of circuits having a higher velocity and the circuits used for long distance cable transmission today have a velocity of about 20,000 miles a second. This is quite adequate for the distances, running up to 2,500 miles, for which cable is used in telephony at the present time. Nevertheless, the time intervals required for transmission are quite appreciable, the interval for 2,500 miles being approximately one-eighth of a second in each direction, and for the much longer cable circuits which are expected with future extensions of the cable network, higher velocities of propagation will be used.

Associated with these and the smaller intervals corresponding to smaller distances are some interesting phenomena which affect the clearness of transmission. One of these is described as an "echo." It results from the fact that the telephone currents, transmitted at high efficiency over the telephone circuit, are partially reflected at the end of the circuit and return to the telephone of the talker. If the time required is more than a few hundredths of a second, even a small percentage of returned current is noticeable as "echo" and produces a certain amount of interference with the conversation. The greater the loudness of the echo or the greater the time delay, the greater is this interference.

Another type of effect results from the fact that the different frequency components of the telephone currents tend not to be transmitted at exactly the same speed. The result is that certain components of the voice currents arrive a little before others, with a resulting distortion of the quality of the speech. This type of effect is graphically illustrated by waves in water which have a large amount of distortion of this kind. Figure 10 shows the wake of a boat. If water waves were without distortion the wake would consist of long uninterrupted crests and troughs, the angle with reference to the direction in which the boat is traveling showing the relative speed of the boat and of the wave. Actually in deep water the low frequency components of waves travel more rapidly than the high frequency components. The resulting distortion of wave shape leads to the form of wave shown in the photograph in which the main body of the wake appears to be broken up into a number of short sections and each short section appears to travel more rapidly than the group of waves as a whole. It is clear that if one should endeavor to transmit speech by creating water waves having the form of articulate sound, it would not be intelligible at the receiving end because of the great distortion of wave shape during transmission, the low frequency components arriving earlier than the higher frequency components.

In telephone circuits fortunately the difference in velocity of transmission, or the delay distortion as it is commonly called, is relatively small. It may, however, under some conditions have an important effect on the talking efficiency. Figure 11 illustrates this fact. It shows a compound wave consisting of 800 cycles and 1,600 cycles transmitted over 600 miles of medium heavy loaded cable circuit. It will be noted that the 1,600-cycle components were received at a time materially later than the 800-cycle components. Figure 12 shows the same type of effect with an impulse of single frequency current. Here the effect can be described as a gradual building up and a gradual dying out at the ends of the impulse as it is received at the end of the circuit, that is, the transient effects which accompany the transmission of the impulse. These effects depend on both the type and the length of circuit, and in practise they are limited to amounts considerably less than shown in the figures by limiting the length for which each type of circuit is used.

Conclusion

This review of the factors which determine the talking efficiency of telephone circuits, because it is brief, is necessarily superficial. It is intended, however, to indicate in a general way what the problem is and how it has been tackled. In many respects these problems dealing with complicated electrical phenomena are very rewarding things to work with. They are sufficiently complex and difficult to stimulate interest and effort, yet they are not wholly recalcitrant for they yield, one after the other, to the assault of the scientist and engineer. And while from the standpoint of electrical phenomena, results are obtained which are quite tangible and definite, and can easily be verified by experience, the author hopes it is quite clear that the problem is much more than an electrical problem. The measurement of the degree to which the telephone circuit satisfactorily fulfills its function of enabling people to talk easily with one another at a distance involves not only the electrical and acoustic characteristics of the circuits and telephone instruments, but also the study of service from the standpoint of the satisfaction derived by those who use it. It is an illustration of a recurring problem whose solution has been one of the great things that has stimulated the development of modern commerce and industry, that is, the measurement of results achieved not on the basis of some technical effect which happens to be easy to measure, but from the broader point of view of determining as nearly as possible the degree of satisfaction given to the customer.

H. S. OSBORNE

Protection Against Lightning

Editor's Note:

The April issue of the BELL TELEPHONE QUARTERLY *contained an article on Lightning, which referred in general to various investigations in that field together with some of the resulting facts and theories. The following article deals more particularly with methods of protection against lightning.*

PROTECTION OF STRUCTURES

FRANKLIN'S proposal to protect buildings by lightning rods led to many interesting incidents. Since lightning was looked upon by many as an instrument of punishment for human wickedness, the use of lightning rods was vigorously opposed by the superstitious element in the church. In several instances mobs of fanatics tore down the "heretical rods," as they called them. In one such case in northern France which resulted in litigation, Robespierre, at that time an unknown young man, was the lawyer who pleaded in court in behalf of the lightning conductors and won the suit.

After Franklin set his hand to the Declaration of Independence, the opposition to lightning rods in England assumed somewhat of a political aspect. For years a controversy raged as to whether the air terminals for the rods should be topped with balls or sharp points, the use of points, as recommended by Franklin, finally prevailing.

The first installation of lightning rods on a public building in Europe was that on the Church of St. Jacob in Hamburg in 1769. The use of rods spread rapidly in northern Germany. Gradually in the southern countries of Europe also, lightning conductors gained in favor, largely through the activities of a few enthusiasts. One night, under cover of darkness, a zealous follower of Franklin installed rods on the Cathedral at Siena. This created great indignation but the enemies of the rods were appeased when they found, after a heavy storm during which the Cathedral was terrifically bombarded by lightning, that the structure remained uninjured. Shortly thereafter rods were erected on the observatory of the University of Padua. Here again an angry crowd became pacified when, after seeing lightning strike the observatory, they found that it caused no damage. On May 9, 1778, the Senate of Venice issued a decree ordering lightning rod protection for public buildings, this being the first official recognition of lightning rods by any government. Important buildings such as the Louvre in Paris, St. Peter's and the Vatican in Rome, and the Houses of Parliament and St. Paul's Cathedral in London, were later equipped with rods.

A remarkable lightning rod installation was designed for the City Hall in Brussels. The equipment was very elaborate and included some 60 "aigrettes" or elevation rods having a total of more than 500 points. The three ground electrodes had a total contact area of more than 2½ million square feet. In 1889 Oliver Lodge said:

> "Of all the buildings in the world not wholly made of metal, the Hotel de Ville at Brussels was and is the most perfectly and elaborately protected. No electrician exists who would not a year ago have asserted, had he gone over it, that it was absurdly and exaggeratedly safe from damage by lightning. Last July it was struck and set on fire."

Thus we see that no system of lightning rods affords absolute protection, although it should be mentioned perhaps that in this case the fire was due to the ignition, by an induced spark, of gas from a leaky main.

In England regulations for the installation of lightning protection were issued by the Lightning Rod Conference in 1881. In 1901, the Lightning Research Committee was organized jointly by the Royal Institute of British Architects and the

Surveyors' Institute. An important report by that committee was presented in April, 1905.

In Germany rules for the protection of buildings were issued by the Electrotechnische Verein in July, 1901.

Specifications for lightning rod protection were issued by the Italian War Ministry in 1919 and by the Swiss Association of Electrical Engineers in 1923.

In Ontario, Canada, regulations covering lightning rod installations were put into effect by the Provincial Fire Marshal in 1922.

In the United States the installation of lightning rods has been carried on largely by manufacturers and contractors without public regulation. For many years lightning rods were sold to farmers and others by traveling agents, many of whom supplied inferior material at inflated prices. Often the lightning rods were not properly installed and no attention paid to their maintenance. As a result lightning rods fell into disrepute and the idea widely prevailed that they were nothing but a humbug. Gradually, however, this misapprehension was dissipated, as more competent persons gave attention to the subject and the business of manufacturing and installing the equipment passed into more reliable hands.

A circular on protection against lightning was issued by the U. S. Bureau of Standards in 1915 and the U. S. Weather Bureau also has issued several bulletins on the subject. In 1921 a joint committee was formed by the national organizations interested, to codify approved practice in lightning protection. The outcome of this work, a "Code for Protection Against Lightning," was approved by the American Standards Association, April 4, 1929. The code has been printed as "Miscellaneous Publication of the Bureau of Standards, No. 92." Practically identical specifications have also been issued by the National Fire Protection Association.

Protection by Lightning Rods

When lightning strikes a building, a large amount of energy is suddenly impressed upon the material through which the current passes. Much of this energy is converted into heat and the material in the lightning path, if combustible, is liable to be set afire. If the material is non-combustible, such as brick or stone, moisture or other matter contained in it may be volatilized by the heat and the resulting gas, expanding with explosive violence, may split or shatter the material.

The purpose of lightning rods is to provide a path by which a discharge from a thunder cloud above the building may reach earth without passing through the material of the building itself. Visualizing the discharge as progressing downward from cloud to earth, the first essential of a lightning rod installation is to provide at the top of the building means for intercepting the lightning current as it comes from the cloud. For this purpose vertical conductors called "elevation rods" are placed at intervals along the ridgepole or other topmost part of the building. These elevation rods are usually about 2 feet in height, but in some cases may be 4 or 5 feet high in order to extend above chimneys or other vertical projections. From considerations of mechanical strength the elevation rods have to be of substantial construction and suitably braced. It is customary to terminate the tips of the elevation rods in "points" since the discharge of a charged body tends to concentrate at any sharp points which the body may have. It has even been supposed by some that the points of a lightning rod installation are able to draw the electricity out of the cloud silently and continuously and thus make impossible the occurrence of violent and dangerous strokes. This supposition, however, is erroneous, as can readily be seen by comparing the physical dimensions of lightning strokes with the maximum distance through which the influence of a "point" could possibly extend, and it is now recognized that the use of points is of minor importance.

After capture of the discharge from the cloud by an elevation rod, the next essential is to keep the lightning current on the lightning rod system until it is conveyed safely to earth. To accomplish this the bases of the elevation rods are connected to a system of metallic conductors coursed along the ridgepole, or other pinnacle of the roof, and down the corners or sides of the building to the ground in such a way as to approximate roughly an enclosing network. For a small or medium building, down-conductors at two or three corners respectively are usually sufficient, but on a large building four or more down-conductors are desirable.

The lightning conductors need not be insulated from the building. Any metal such as gutters, leaders, flashing, etc., is bonded to the lightning rod system, as are also pipes and other large objects of metal inside the building, unless the lightning conductors are kept 6 feet or more away from such interior metal.

Each down-conductor is extended to earth and connected to an underground electrode, for which purpose an extensive metallic water piping system is most effective. Where a water pipe is not available, the best earth connection can usually be secured by means of driven pipes or rods, the individual rods being 6 feet or more apart and securely bonded together.

The lightning conductors may be of copper or of galvanized or copper covered steel and may be in the form of stranded cable, solid rod, or tubular or other cross-section, such as tape or ribbon. The kind of metal employed or its size or form is not of great importance so far as determining the discharge path is concerned, but is governed by considerations of mechanical strength, durability, facility in handling and in making connections, etc.

Protection by Means Other Than Rods

Buildings of steel frame construction and buildings covered with metal sheathing or having metal roofs do not require lightning rods, but the metal should be thoroughly grounded. A building situated amidst tall trees derives substantial protection from the trees. A metal tower, such as a windmill, if within 50 feet or so of a building, offers material protection, particularly if it is taller than the building. An array of tall metal masts or poles, thoroughly grounded and interconnected, encircling a building would probably afford better protection than lightning rods. A deposit of radium or other radioactive substance produces, by ionization of the air, a conductive path for lightning, and such a deposit might constitute reasonably effective protection for a near-by house.

Where it is deemed advisable to equip a structure with lightning rods, the specifications contained in the national Code for Protection against Lightning represent accepted modern practice. It is, of course, important that the installation be supervised by an engineer or other competent person experienced in this field.

Special Types of Structures

Towers, monuments, stacks and other unusually tall structures, are more exposed to damage by lightning than ordinary buildings and the national Code for Protection against Lightning includes special precautions for such structures. The Washington Monument, for example, has been struck by lightning repeatedly and, before the lightning rods on it were properly interconnected with the structural metal, was considerably damaged.

Structures containing highly inflammable material such as oil tanks, gas holders, etc., are particularly hard to protect against lightning and the national Code contains a special section devoted to structures of this kind. In an ordinary lightning rod installation there is a possibility that small sparks may be induced between metal objects not thoroughly bonded together. The occurrence of such sparks in ordinary buildings may not be important, but in structures containing inflammable liquids or gases, is liable to cause fires or explosions. Even with the extreme precautions observed in this special class of structures, the protection obtainable can not be considered absolute.

Effectiveness of Rods

There is no adequate information available to show just how effective lightning rods are in protecting an ordinary building. Merely as an expression of the writer's opinion, the chance of fire or mechanical damage by lightning to a properly rodded building is probably of the order of 10 per cent of what it would be with no protection.

Economics of Lightning Protection

In most localities lightning constitutes a substantial fire hazard to rural structures, particularly barns and silos which, being large, and possibly also harboring sources of ionization, are targets for strokes of lightning. The fire loss from lightning in the United States averages about $12,000,000 per year, practically all in rural areas.

From a strictly economic standpoint, the property loss due to lightning is not large enough to justify rodding all farm buildings, even if it be assumed that such rods afford 100 per cent protection, as the annual charges for the rods would amount to many times the total annual property loss from lightning. Obviously, therefore, economic justification for lightning rods can be found only where some unusual condition exists, which warrants extraordinary precautions against damage, such as unusually severe exposure, or unusual importance or value of building or contents. Of course the direct property loss of a burned building may not be the whole story. Indirect losses from inconvenience, interruption of use, and disturbance to operations on the premises, may exceed the appraisable property loss.

Effect on Personal Safety

We have seen that the air behaves in part like an insulator and in part like a conductor, the conductive regions being those in which, for the moment, free ions are abundant. When the space immediately about us becomes highly ionized, we find ourselves virtually inside a conductor and if this conductor happens to become a discharge path for lightning, our conductive bodies may be commandeered by nature to reinforce the conductive air with unpleasant or disastrous consequences.

While some people are beset with fear during thunder showers, actually the danger is small, particularly to persons inside buildings. The number of persons killed by lightning in the United States is, on the average, about 500 per year, which is less than one-twentieth of 1 per cent of deaths from all causes. In addition, there are in an average year some 1300 cases of shock by lightning which do not result fatally and most of which leave no serious effects. Statistics do not show how many of the injuries due to lightning occur to persons indoors, but it must be a small percentage of the total cases. Inside buildings of steel frame construction or having wall and roof coverings of grounded metal, there is practically no danger. To be inside a building of any kind is much safer than to be out in the open during a heavy thunder shower.

The question is often asked, do lightning rods insure safety to persons inside the rodded buildings? Undoubtedly the rods promote safety, but it may be worth while to examine the matter more closely. Proper installation requires that lightning rods be interconnected with conduits, pipes, and other extensive bodies of metal in the building. When the rods are struck they become momentarily charged to a high potential and this high potential is communicated to the interconnected metal. If a person should be touching a water faucet, for example, at the instant of a lightning stroke, he would be more liable to receive a shock than if the building were not rodded. For a condition of this kind the lightning rods enhance, rather than reduce, the personal hazard. But if one keeps well away from the rods and all other large metal objects, the lightning conductors help to prevent the discharge from reaching his body and hence reduce the chance of shock.

When out of doors and away from buildings during a thunder shower it is natural to seek shelter under a tree, but an isolated tree in an open space is an inviting path for lightning and if the tree should be struck, a person under it would be liable to be injured. On the other hand a forest or grove affords a degree of protection because a lightning discharge in the vicinity would probably not be intercepted by the particular tree under which the person is sheltered.

Hollows, depressions, and low places generally are less subject to lightning than higher elevations, other things being equal. However, such differences in exposure may be entirely overshadowed by other factors. Thunder storms travel in courses determined largely by the local topography, direction of winds, proximity to water bodies, etc.; hence the influence of position on the liability to a lightning stroke can best be determined by local experience and observation.

Protection of Electric Power and Communication Lines and Apparatus

Most long distance communication circuits, practically all power transmission circuits, and most of the longer power distribution circuits, are of open wire construction and so require protection against lightning to a greater or less extent according to their importance and severity of exposure. A substantial amount of protection can be obtained by means of one or more shielding conductors carried along the line above the circuit conductors and grounded at frequent intervals. Such shielding is in use on many high voltage transmission lines in severe lightning areas. Also there is a growing tendency to attempt control over the number and location of failures by co-ordination of insulation, "co-ordinating gaps," and other design features of lines and equipment. Relatively simple devices of tubular form, such as "expulsion gaps," "flashover protectors," etc., are being proposed for use in conjunction with external series gaps for protecting line insulators. The purpose is to afford a by-pass for lightning discharges, the devices being constructed with the idea of quickly extinguishing the follow-up current and so reducing insulation failures and circuit outages. As a further protection, particularly to apparatus, "lightning arresters" are employed on most exposed circuits. The arresters provide a path to earth for the lightning current, thus diverting it from the equipment to be protected. Such a device may be likened to a safety valve, its function being to relieve the abnormal electric pressure due to surges suddenly imposed on the circuit, before the abnormal stress breaks down the insulation which is being protected.

Protection of Communication Lines

From the earliest days of long distance electrical communication, it has been found necessary to use lightning arresters where aerial conductors of considerable length, and not in cable, are employed. The arresters are generally located at the junction of the exposed circuits and the plant to be protected. Conductors in metal sheathed cables, not connected to open wires or connected only to short lengths of open wire, are so well shielded that the effects of lightning on them and on their associated apparatus are usually negligible.

The protection used on communication circuits generally includes fuses although the purpose of the fuses is not to protect against lightning. Their use is due to the fact that in most cases the lines which are exposed to lightning are also exposed to the liability of accidental contact with electric power wires. Where exposed to such wires which carry more than about 250 volts, a fuse is needed in addition to a spark gap, the latter to provide a path to ground for lightning or other abnormal current, the former to interrupt the current, if it is large enough to destroy the device or to start a fire.

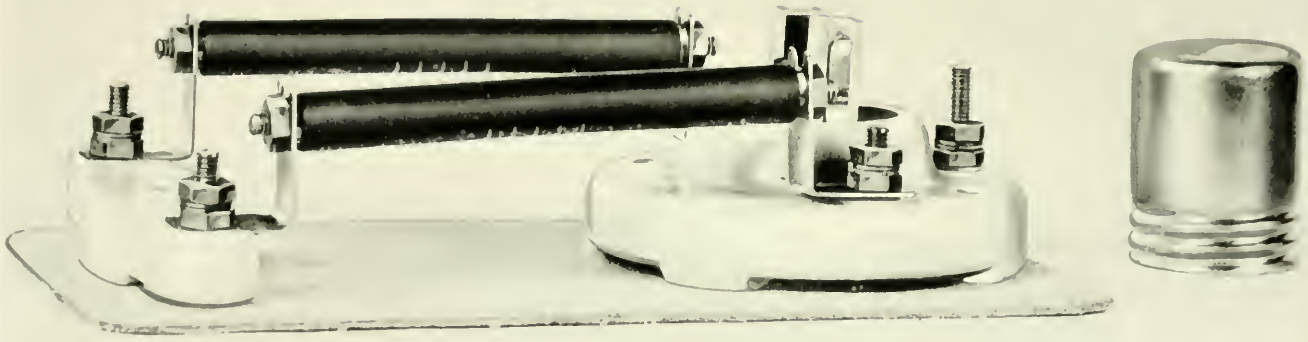
Lightning arresters for communication circuits are designed on the principle of providing a discharge path for currents due to abnormal voltages, this path being in parallel with the portion of plant to be protected. The arresters are so designed and constructed that under normal conditions they do not divert any of the operating currents from their normal paths.

The arrester part of the protector commonly used on communication circuits is a simple spark gap, comprising two electrodes, separated from each other by an air gap of such size that it will break down and pass current from one to the other when the voltage between them exceeds a given value. In the arresters ordinarily used this air gap is of the order of .003 inch, and breaks down at about 300 volts.

In another class of lightning arresters used to a limited extent on communication circuits, the discharge takes place across a gap enclosed within a partial vacuum. Another type of arrester which is being developed makes use of a material having a critical voltage-resistance characteristic, that is, the material has a high resistance at the normal operating voltage of the circuit but a much lower resistance at higher voltages.

A great deal of work has been done in developing different materials for arrester electrodes and in experimenting with different shapes, dimensions, and methods of construction, in order to determine how the best results can be obtained. The present form of station protector is illustrated in Figure 1 and further details of construction are shown in Figure 2.

When installing the arresters, one of the two electrodes is connected to a conductor of the circuit to be protected, and the other electrode is connected to a ground, consisting of a water pipe if one is available, otherwise usually a rod driven into the earth. This type of arrester has functioned with a high degree of effectiveness, under its usual service conditions. The chief problem has been to obtain a device which, while



STATION PROTECTOR

Figure 1.

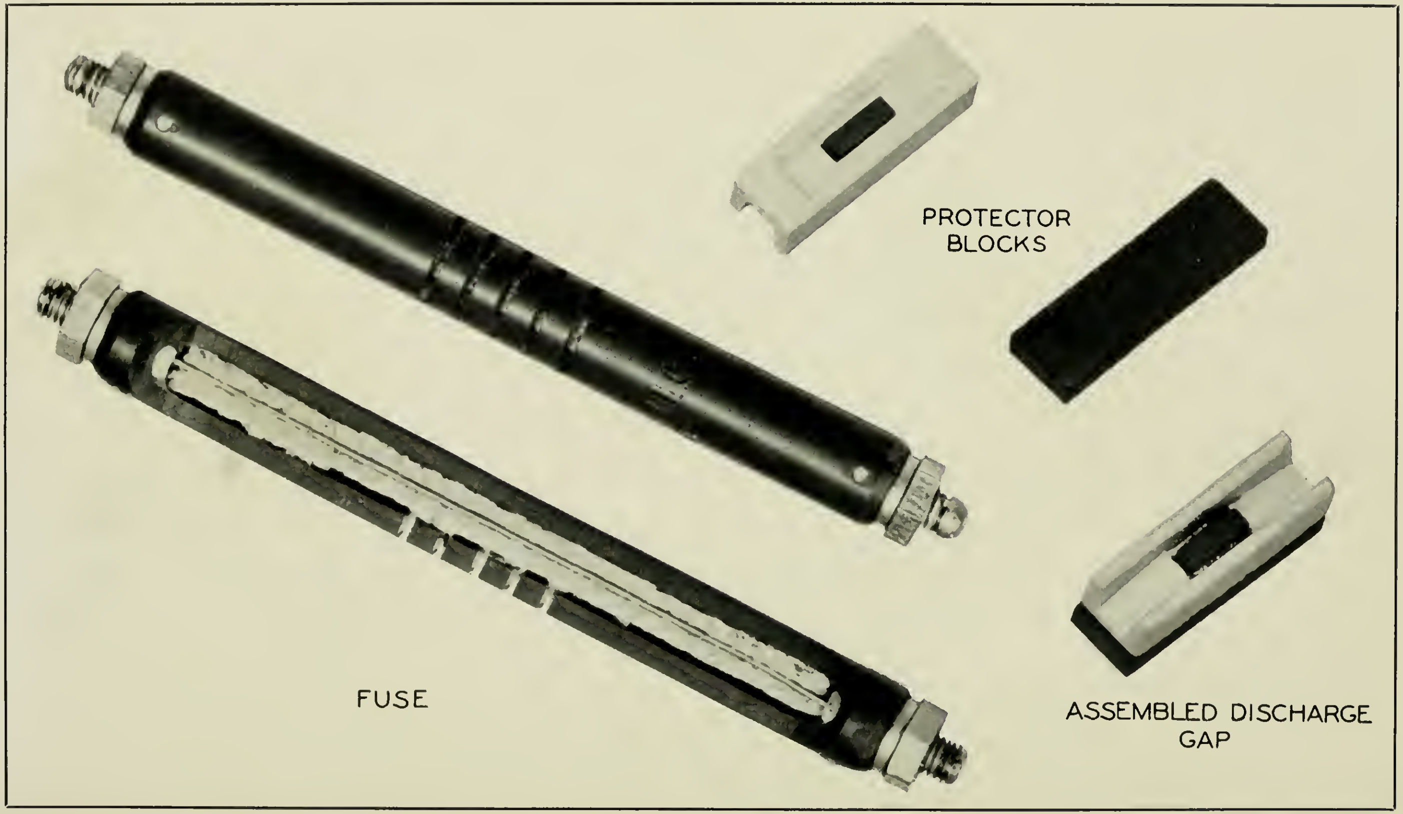


FIGURE 2.

adequate for protecting the cables and apparatus, would not suffer damage itself, thus disabling the circuit and causing interruption of service. It has been found that this trouble is reduced to a minimum by using electrodes of certain special types of hard carbon. However, the grounding of arresters is still a material source of trouble and the problem of improving the device is still an active one.

In areas where lightning is very severe it has been proposed to use two spark gaps in parallel, the second or auxiliary spark gap being of larger and more rugged construction than the regular one. The auxiliary gap is placed one or more poles away from the station protector, and is intended to take part of the discharge which otherwise would have to be handled by the regular arrester. This arrangement tends to lessen the chance of the discharge leaving the protector grounded and so causing interruption to service.

Arresters used at the junction of open wire and cable are similar to those used at subscribers' stations except that the spacing between the electrodes is somewhat greater. Formerly it was the practice to ground the cable arrester to a rod driven in the earth at the base of the pole, on the assumption that the most direct path to earth would afford the best protection. However, it has been found that the potential of the cable conductors due to lightning follows closely the potential of the cable sheath and that the cable can be protected more effectively by connecting the ground side of the arrester to the lead sheath of the cable rather than directly to earth. In this way the potentials of the cable conductors, the cable sheath, and the exposed open wires, are substantially equalized.

Most of the potentials imposed on communications wires by lightning are due to induction from strokes in the vicinity of the exposed lines. Direct strokes of lightning on telephone plant are of relatively infrequent occurrence.

The poles on which telephone wires are supported are sometimes shattered by lightning. In the early days of the telephone it was the practice to carry a grounded conductor as a lightning guard wire along the top of the pole line, this conductor being tapped to earth every fifth or tenth pole. Later it became the practice to equip every tenth pole only with a wire down the pole to ground, like a lightning rod, the guard wire being omitted. Still later it came to be believed that even the vertical wires were not justified and their use was abandoned.

Recent experiments have indicated that the shattering of poles by lightning can be largely prevented by a wire extending from the top of the pole down to a point just below the lowest attachment on the pole, and terminating there instead of being carried clear down to earth. This arrangement avoids some, but not all, of the objections to the earlier types of pole protection and further study is being given to it.

For several years field tests have been conducted during the lightning season for the purpose of acquiring additional data on lightning behavior and characteristics incident to the problem of protecting telephone and telegraph systems.

Protection of Electric Power Lines and Apparatus

In the application of lightning arresters to electric power lines, the purpose is to protect, not only against lightning surges but also against sudden severe impulses due to other causes, such as switching, etc. A difficult feature of the problem is to obtain a device which will conduct the surge to earth before the potential rises to a dangerous value and at the same time will not permit the power current to follow up the arc; for power current follow-up would not only ground the circuit and interrupt service but would probably also destroy the arrester. For such service a simple spark gap is not adequate, except possibly for very low voltage circuits. In general, all arresters used on power circuits are provided with some means for interrupting the arc, as soon as the surge has disappeared.

All through the development of the electric power and lighting industry much attention has been given to the development of these protective devices. Many different forms of lightning arresters have been developed, most of which, after a period of more or less successful use, have been supplanted by new types of better design or greater effectiveness. Some of the more important of these arresters will now be mentioned.

The "Magnetic Blowout" Arrester

The "magnetic blowout" arrester dates from as early as 1881 and is still in use on railway and other direct-current circuits. In this arrester the spark gap electrodes are the poles of an electromagnet, the field of which, built up by the discharge current, extinguishes the arc.

The "Horn Gap" Arrester

In the early days of alternating-current power circuits, protection was attempted by the "horn gap" arrester. This consists essentially of a simple spark gap surmounted by a pair of V-shaped prongs, up which the arc is borne by the heated air and by magnetic influence until the arc, by increased length, becomes extinguished. As such an arrester is not adapted to carry heavy currents, series resistance was used to limit the current. This device has not for many years been generally used as an arrester by itself, but it has served a purpose as an element in protection arrangements in conjunction with later type arresters.

The "Multi-Gap" Arrester

Some thirty years ago, as power circuits of larger capacity came into use, an important advance in lightning protection was effected by the development of the "multi-gap" arrester. This consisted of a number of gaps in series between cylinders of "non-arcing metal," an alloy of low and high boiling point metals, the former to permit an arc to form at low temperature, the latter to hold the cylinders in shape. Due to capacity effects, the surge voltage would not distribute evenly among the gaps, but the voltage across the end gap would be greatest. Consequently this would break down first, after which the greatest voltage would be impressed across the next gap, which would then break down, and so on. The operating circuit voltage, however, being of low frequency would distribute equally among the gaps, and under this condition none would break down. Furthermore, the power arc, which followed a surge discharge, would not re-form after extinction at the end of the half cycle. To care for surges of different wave fronts, etc., resistances were sometimes used in series or shunt with some or all of the gaps so as to form several discharge paths of different electrical characteristics. The arresters were often connected to the line through simple spark gaps shunted by fuses.

The multi-gap arrester was fairly satisfactory on low voltage circuits such as 2300-volt distribution circuits, but on higher voltage circuits, such as are used for transmission, the spark gap type of arrester was found incapable of extinguishing the arc quickly enough always to prevent the arresters from being destroyed and the circuits from being put out of service. About this time also various devices, many of which were essentially variants of simple air gaps, such as arcing rings for transmission line insulators, came into use. As the nomenclature was getting to be confused it was decided that the term "lightning arrester," as applied to protective apparatus for power systems, should henceforth be used only to indicate devices which, after being operated, would automatically restore to normal condition.

The "Aluminum Cell" Arrester

The electrolytic or "aluminum cell" arrester was the first important example of the so-called "valve" type, i.e., an arrester having an element which passes current freely at impressed voltages in excess of a certain value, and which ceases almost completely to pass current at impressed voltages below a certain value. A horn gap or other spark gap is connected in series with this arrester.

The arrester comprises a series of cells having aluminum electrodes and an electrolyte in which aluminum is not soluble. In such an electrolyte a film of aluminum oxide forms on the electrode surfaces. This film breaks down at about 350 volts, but at any lower voltage is non-conducting. The current resulting from breakdown, however, restores the coating to its non-conductive state. By placing a sufficient number of such cells in series, any predetermined breakdown voltage can be obtained. This breakdown and the resulting restoration to the non-conductive condition, make the aluminum cell arrester act, towards an overvoltage, like a counter-electromotive force of magnitude equal to the normal circuit voltage. The discharge through the arrester is therefore limited to the short-circuit current of the over-voltage, the energy of which is small compared to the short-circuit capacity of the power circuit.

This arrester proved to be quite effective as a protector and came into extensive use, but its operating and maintenance cost was high, since, in order to maintain the film of aluminum oxide, it had to be charged daily by short-circuiting the series gaps for a few seconds. Also at very low temperatures the electrolyte would freeze and the protective properties become lost.

There are still quite a number of arresters of this type in service, but in recent years they have not usually been employed in new installations of alternating-current systems.

The "Oxide Film" Arrester

The next important improvement in the lightning protector field was the "oxide film" arrester, which also functions on the "valve" principle in a manner closely resembling the aluminum cell arrester, but has the advantage that it contains no electrolyte and does not require charging. The oxide film arrester comprises a series of cells, each consisting of two circular metal plate electrodes, mounted on, and held apart by, a porcelain ring. The space inside the ring between the electrodes is filled with lead peroxide which is a good conductor, but when current passes through it, a film of the material in the current path is reduced to a lower oxide of lead which is an insulator. This insulating film grows in thickness until it cuts off further flow of current. The film can withstand a voltage up to about 300 volts per cell. At a higher voltage the film is punctured and the over-voltage is discharged, but in so doing, the current converts the surface of the lead peroxide in the path into the non-conducting oxide, thereby closing the puncture holes and restoring the insulating film.

In its practical form the arrester is built up of a number of cells proportioned to the voltage of the circuit on which it is used. This arrester also is connected to the line through a spark gap arrangement, usually a combination of sphere gap and horn gap.

The oxide film arrester has been extensively used and has proved quite satisfactory. For lower voltage systems such as power distribution circuits, where the cost of the arrester is an important item, a pellet type of oxide film arrester has been developed, the material of which consists of lead peroxide pellets coated with a film of insulating lead oxide powder as a spacer. A high voltage discharge breaking down these films divides among a number of paths through the pellets. Recovery of the insulating coating occurs at the contact surfaces where the current passes.

The "Autovalve" Arrester

The "autovalve" arrester, as its name implies, is another of the valve type arresters. In its newer form the arrester element is a composite of a porous non-conducting material and finely divided conducting material. Between the conducting particles of the material, minute air gaps occur. The composite material is practically an insulator until sufficient voltage is impressed upon it to cause breakdown of the minute air gaps, in which event, due to its structure, numerous separate discharge paths are set up, but without sufficient current concentration or local heating in any path to cause an arc. In the absence of arcs a considerable voltage is required to force the current through the material. Therefore when the voltage is reduced, the discharge across the small gaps in the material can no longer be maintained, and the current practically ceases. The small remaining current is readily interrupted by a main series spark gap.

The individual blocks of the autovalve material as now used are rated at 3000 volts each, the arrester being built up of different numbers of blocks according to the line voltage.

The "Thyrite" Arrester

In the "thyrite" arrester the element in series with the spark gap consists of a specially prepared material, which instead of containing within itself discontinuities in different conducting paths, is a substantially homogeneous conductor which has the property that its resistance to large voltages is very much less than to small voltages. Thyrite is a molded material, the composition and characteristics of which may be varied considerably, but in one particular form the current increases 12.6 times when the impressed voltage is doubled. A disk of this material 6″ in diameter and ¾″ thick, will pass one ampere of current when subjected to 580 volts, 12.6 amperes when subjected to 1160 volts, and over 150 amperes when subjected to 2300 volts. It can readily be seen that an arrester of such material will pass only a very small current at normal circuit voltage, while offering comparatively little resistance to high over-voltages.

In its commercial form this arrester is built up of units rated at 11,500 volts, each unit consisting of a stack of 11 disks, the number of such units in the complete arrester being determined by the line voltage. The arrester is connected to the line through a spark gap.

The "Crystal Valve" Arrester

Another lightning arrester, used chiefly on power circuits not exceeding 30,000 volts, is the "crystal valve" which resembles somewhat the autovalve and thyrite arresters in respect to operation. In this case, however, the arrester is not built up of blocks or unit groups of blocks, but the special material is all in one piece, the dimensions of which are determined by the voltage rating of the arrester. Each arrester contains a series multi-spark gap element.

Other arresters of the valve type have been developed, but the above is thought to include those in most common use. It should be stated that in addition to the lightning arrester proper, it was formerly customary to provide choke coils ahead of the apparatus to be protected, the object of these coils being to help divert the surges away from the apparatus and towards the arresters. Most engineers however now question the utility of choke coils for this purpose and although many such coils are still in use, they are no longer generally employed in new installations. The use of series air gaps and, in some cases, series resistances, has been referred to, but it may not be appreciated that a spark gap, which would seem to be a very simple thing, may be in practice a large, complicated, and expensive device.

The foregoing scarcely more than hints at the enormous amount of time, effort, and expense which have been devoted to the development of lightning arresters. The modern arresters resulting from this effort represent a great advance in effectiveness of protection against lightning, but it must be remembered that the influence of a single arrester extends only over a limited area. While arresters have been simplified in design and reduced in cost, it is still true that the expense of providing them, even for merely limiting failure of equipment, is an important item. Many more arresters and a much larger expense would be required if an attempt were made to protect all parts of a power system against surges which may cause faults or trip-outs. The number of arresters to be employed in any specific situation is an economic question and has to be determined in accordance with the circumstances prevailing.

CONCLUSION

In conclusion it is again emphasized that in many respects and to a large extent, lightning is still a mystery. Both electrically and meteorologically it is unique. The ratio of surmise to knowledge about it is high. The practical questions of protecting structures and electrical systems against damage by lightning are better understood than are the theoretical features. While nature is being forced slowly but surely to yield up her secrets, there will probably be many decades of further study and investigation before a satisfactory understanding of lightning as a physical phenomenon is attained.

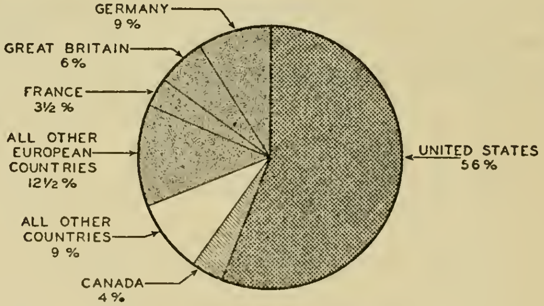
HOWARD S. WARREN

World's Telephone Statistics

January 1, 1932

THE usual annual survey of the world's telephones was completed recently by the Chief Statistician's Division of the American Telephone and Telegraph Company. According to this latest survey, the total number of telephones in the world as of January 1, 1932, was 35,057,669. At that date the United States had 19,690,187 telephones, or about 56.2 per cent of the world's total. Europe had 10,871,581 telephones, representing 31 per cent of the total number in the world.

DISTRIBUTION OF THE WORLD'S TELEPHONES
January 1, 1932



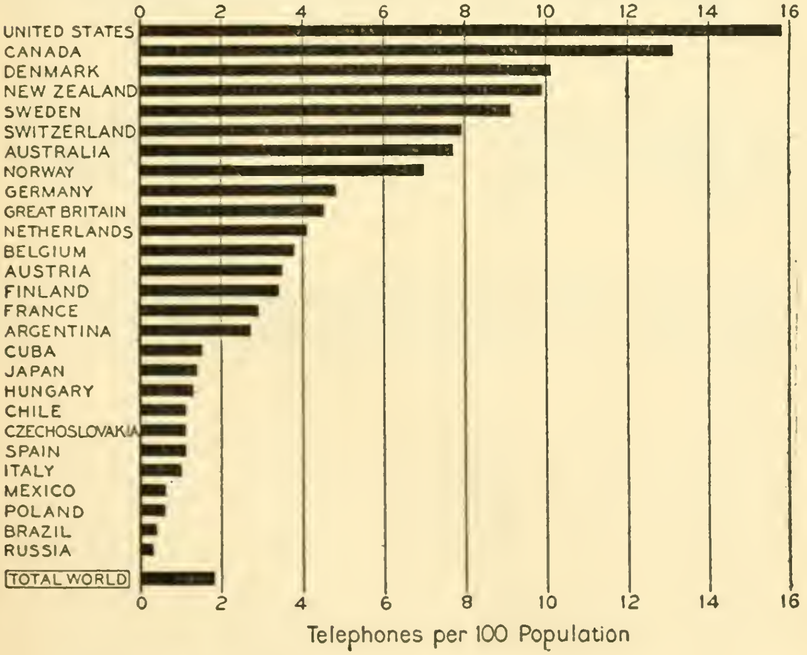
The remaining 4,495,901 telephones, or about 12.8 per cent, were distributed among the countries of Asia, Africa, Oceania and the Western Hemisphere outside of the United States.

The results of the survey have been issued in an eight page pamphlet entitled "Telephone and Telegraph Statistics of the World, January 1, 1932"; and the accompanying tables and charts have been reproduced from this document.

COMPARATIVE TELEPHONE DEVELOPMENT OF COUNTRIES

The United States, with a development of 15.8 telephones per 100 inhabitants, maintained its position of preeminence among the countries of the world in respect of the extent of telephone facilities in relation to population. Canada was second, with a development of 13.1 stations per 100 population. Then follow in order, Denmark with 10.1, New Zealand with 9.9, and Sweden with 9.1 telephones per 100 population, respectively. It is interesting to note that private operation of the telephone service predominates in the three leading countries from the standpoint of facilities for oral communication by wire. In the United States all telephones are privately owned, while in Canada and in Denmark, private companies operate respectively 84 per cent and 96 per cent of the total instruments in service. Of the major European countries, Germany had a development of 4.8 telephones per 100 inhabitants—less than one-third that of the United States.

TELEPHONES PER 100 POPULATION
January 1, 1932



TELEPHONE DEVELOPMENT OF THE WORLD, BY COUNTRIES

January 1, 1932

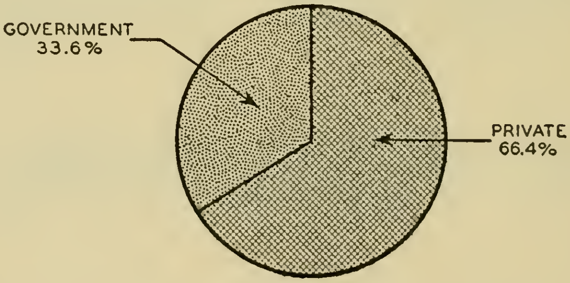
Countries	Number of Telephones			Percent of Total World	Telephones Per 100 Population
	Government Systems	Private Companies	Total		
NORTH AMERICA:					
United States		19,690,187	19,690,187	56.17%	15.8
Canada	223,186	1,141,014	1,364,200	3.89%	13.1
Central America	11,317	14,439	25,756	.07%	0.4
Mexico	1,427	92,086	93,513	.27%	0.6
West Indies:*					
Cuba	485	55,098	55,583	.16%	1.5
Porto Rico	589	11,662	12,251	.04%	0.8
Other W. I. Places *	7,985	13,970	21,955	.06%	0.3
Other No. Am. Places *	100	11,900	12,000	.03%	3.3
Total	245,089	21,030,356	21,275,445	60.69%	12.5
EUROPE:					
Austria	239,809	—	239,809	.69%	3.5
Belgium (February 29, 1932)	313,022	—	313,022	.89%	3.8
Bulgaria	17,551	—	17,551	.05%	0.3
Czechoslovakia	150,284	18,859	169,143	.48%	1.1
Denmark (March 31, 1932)	14,899	349,609	364,508	1.04%	10.1
Finland	1,597	125,900	127,497	.36%	3.4
France	1,228,879	—	1,228,879	3.51%	2.9
Germany (March 31, 1932)	3,113,655	—	3,113,655	8.88%	4.8
Great Britain and No. Ireland	2,080,056	—	2,080,056	5.93%	4.5
Greece *	13,000	—	13,000	.04%	0.2
Hungary	116,597	—	116,597	.33%	1.3
Irish Free State (March 31, 1932)	31,994	—	31,994	.09%	1.1
Italy (June 30, 1931)	—	440,392	440,392	1.26%	1.0
Jugo-Slavia	37,488	—	37,488	.11%	0.3
Latvia (March 31, 1932)	53,883	—	53,883	.15%	2.8
Netherlands	325,799	—	325,799	.93%	4.1
Norway (June 30, 1931)	118,355	78,900	197,255	.56%	7.0
Poland	101,939	92,209	194,148	.55%	0.6
Portugal	10,754	31,000	41,754	.12%	0.6
Roumania	—	50,050	50,050	.14%	0.3
Russia† (October 1, 1931)	462,931	—	462,931	1.32%	0.3
Spain	—	252,500	252,500	.72%	1.1
Sweden	558,956	1,649	560,605	1.60%	9.1
Switzerland	324,088	—	324,088	.93%	7.9
Other Places in Europe*	100,520	14,457	114,977	.33%	1.4
Total	9,416,056	1,455,525	10,871,581	31.01%	2.0

SOUTH AMERICA:					
Argentina*	—	313,598	313,598	.90%	2.7
Bolivia	—	2,093	2,093	.01%	0.1
Brazil*	680	165,024	165,704	.47%	0.4
Chile	—	48,130	48,130	.14%	1.1
Colombia*	2,500	27,000	29,500	.08%	0.3
Ecuador	2,968	3,300	6,268	.02%	0.3
Paraguay	—	2,931	2,931	.01%	0.3
Peru	—	14,632	14,632	.04%	0.2
Uruguay	—	29,691	29,691	.08%	1.5
Venezuela	606	21,577	22,183	.06%	0.7
Other So. Am. Places*	2,760	—	2,760	.01%	0.5
Total	9,514	627,976	637,490	1.82%	0.7
ASIA:					
British India*	20,500	34,000	54,500	.16%	0.02
China*	85,000	65,000	150,000	.43%	0.03
Japan (March 31, 1932)	919,605	—	919,605	2.62%	1.4
Other Places in Asia	116,016	15,332	131,348	.37%	0.1
Total	1,141,121	114,332	1,255,453	3.58%	0.1
AFRICA:					
Egypt	44,440	—	44,440	.13%	0.2
Union of South Africa§	113,122	—	113,122	.32%	1.4
Other Places in Africa*	93,176	1,335	94,511	.27%	0.1
Total	250,738	1,335	252,073	.72%	0.2
OCEANIA:					
Australia (June 30, 1931)	498,055	—	498,055	1.42%	7.7
Dutch East Indies	46,104	4,250	50,354	.14%	0.1
Hawaii	—	25,789	25,789	.07%	6.5
New Zealand§	160,779	—	160,779	.46%	9.9
Philippine Islands	6,000*	20,414	26,414	.08%	0.2
Other Places in Oceania*	3,458	778	4,236	.01%	0.2
Total	714,396	51,231	765,627	2.18%	0.9
TOTAL WORLD	11,776,914	23,280,755	35,057,669‡	100.00%	1.8

* Partly estimated.
† U. S. S. R., including Siberia and Associated Republics.
‡ Includes approximately 12,500,000 automatic or "Dial" telephones, of which more than 50% are in the United States.
§ March 31, 1932.

Great Britain had a development of 4.5 and France 2.9 telephones per 100 population. In each of these three countries, the telephone service is operated by the respective Governments. The development of Argentina, 2.7 telephones per 100 population, though very low as compared with that of the United States, is considerably higher than the development of the next highest South American country, namely, Uruguay, which had 1.5 instruments per 100 population. In Asia the majority of the telephones are concentrated in Japan; but even so the Japanese had only 1.4 telephones per 100 inhabitants. The accompanying chart, "Telephones per 100 Population," indicates the relative positions of the principal countries of the world as regards telephone density.

OWNERSHIP OF THE WORLD'S TELEPHONES
January 1, 1932



Telephones in Large and Small Communities

One fact clearly brought out by the annual survey is that in the United States ample telephone facilities are provided not only in the more densely populated urban centers, but in the less populated sections as well. Thus, referring to the table "Telephone Development of Large and Small Communities," it will be noted that the development of 11.8 telephones per 100 inhabitants in communities of less than 50,000 population in the United States is considerably higher than the total

TELEPHONE DEVELOPMENT OF LARGE AND SMALL COMMUNITIES
January 1, 1932

Country	Service Operated by (See Note)	Number of Telephones In Communities of 50,000 Population and Over	Number of Telephones In Communities of less than 50,000 Population	Telephones per 100 Population In Communities of 50,000 Population and Over	Telephones per 100 Population In Communities of less than 50,000 Population
Australia (June 30, 1931)*	G.	284,000	214,055	8.6	6.7
Austria (January 1, 1931)	G.	176,153	57,759	7.5	1.3
Belgium (January 1, 1931)	G.	203,106	89,527	6.1	1.9
Canada	P. G.	732,000	632,200	22.8	8.8
Czechoslovakia	P. G.	66,217	102,926	4.0	0.8
Denmark	P. G.	165,662	196,298	18.0	7.3
Finland	P. G.	49,130	78,367	10.6	2.4
France	G.	715,663	513,216	7.8	1.6
Germany (March 31, 1932)	G.	2,017,437	1,096,218	7.6	2.8
Great Britain and No. Ireland†	G.	1,507,500	601,900	5.8	2.9
Hungary	G.	88,288	28,309	5.0	0.4
Japan (March 31, 1932)	G.	565,053	354,552	3.5	0.7
Netherlands	G.	210,451	115,348	6.6	2.4
New Zealand (March 31, 1932)	G.	62,459	98,320	11.9	9.0
Norway (June 30, 1931)	P. G.	67,921	129,334	16.9	5.3
Poland	P. G.	116,248	77,900	2.6	0.3
Spain	P.	147,447	105,053	3.4	0.6
Sweden	G.	224,483	336,122	22.2	6.5
Switzerland	G.	143,921	180,167	16.9	5.6
Union of South Africa	G.	60,313	52,752	6.3	0.7
United States	P.	10,976,449	8,713,738	21.9	11.8

Note: P. indicates telephone service operated by private companies, G. by the Government, and P. G. by both private companies and the Government. See first table.

* Partly estimated.

† March 31, 1932.

development of all other countries with the single exception of Canada. This relatively high telephone development of less populated regions in the United States becomes all the more striking when it is compared with similar figures for the major European countries. Great Britain, for example, had a development of 2.9 for its less populated sections; the corresponding figure for Germany was 2.8, while in the case of France there were only 1.6 telephones per 100 people in communities of less than 50,000 inhabitants. By comparing these figures with the corresponding development in communities of more than 50,000 population—Great Britain 5.8, Germany 7.6 and France 7.8—it is apparent that the telephone facilities in these foreign countries are concentrated mainly in the cities.

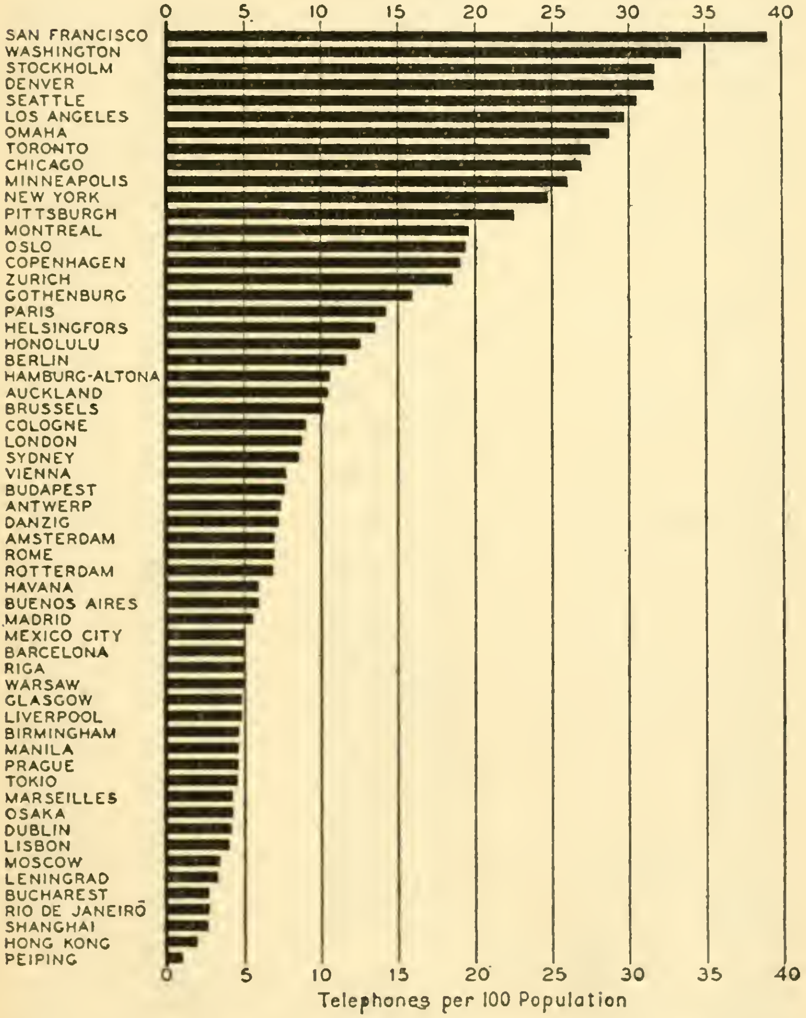
TELEPHONES IN LARGE CITIES

The accompanying chart, "Telephones per 100 Population of Large Cities," shows practically no change from the preceding year as regards the relative position of large cities of the world in respect of telephone development. Thus, of the twelve cities heading the list of selected cities, ten are in the United States. Likewise, the capital cities of Paris, Berlin and London continue to be well down on the list, being eighteenth, twenty-first and twenty-sixth, respectively. San Francisco is again the best developed large city in the world, having 39.1 telephones per 100 population. Washington is second with a development of 33.4, and Stockholm is third with 31.7; then follow in order the American cities, Denver, 31.6, Seattle, 30.5, Los Angeles, 29.7 and Omaha, 28.7.

The accompanying table, "Telephone Development of Large Cities," is supplementary to the chart discussed in the previous paragraph and includes a larger number of cities. This table indicates still more emphatically the marked superiority of the American cities over those in foreign countries as regards telephone density. Thus, the total of 51 American cities having 200,000 population and over, representing a combined population of 36,995,100, had a development of 22.9. With the exception of Stockholm and the Canadian city of Toronto, this

TELEPHONES PER 100 POPULATION OF LARGE CITIES

January 1, 1932



TELEPHONE DEVELOPMENT OF LARGE CITIES

January 1, 1932

Country and City (or Exchange Area)	Estimated Population (City or Exchange Area)	Number of Telephones	Telephones per 100 Population
ARGENTINA:			
Buenos Aires	2,875,000	170,352	5.9
AUSTRALIA:			
Adelaide	325,000	27,999	8.6
Brisbane	317,000	24,559	7.7
Melbourne	1,031,000	91,305	8.9
Sydney	1,256,000	106,231	8.5
AUSTRIA (January 1, 1931):			
Graz	165,000	9,469	5.7
Vienna	2,020,000	155,128	7.7
BELGIUM (January 1, 1931):			
Antwerp	519,000	37,795	7.3
Brussels	948,000	95,632	10.1
Liège	424,000	20,669	4.9
BRAZIL:			
Rio de Janeiro	1,650,000	45,180	2.7
CANADA:			
Montreal	979,000	192,302	19.6
Ottawa	182,200	39,399	21.6
Toronto	752,700	206,968	27.5
CHINA:			
Canton	1,000,000	4,300	0.4
Hong Kong	750,000	13,463	1.9
Peiping	1,400,000	12,583	0.9
Shanghai	1,500,000	38,428	2.6
CUBA:			
Havana	720,000	42,310	5.9
CZECHOSLOVAKIA:			
Prague	870,000	39,658	4.6
DANZIG:			
Free City of Danzig	240,000	17,161	7.2
DENMARK:			
Copenhagen	780,000	148,378	19.0
FINLAND:			
Helsingfors	255,000	34,426	13.5
FRANCE:			
Bordeaux	268,000	17,679	6.6
Lille	212,000	16,043	7.6
Lyons	596,000	31,527	5.3
Marseilles	682,000	28,716	4.2
Paris	3,000,000	426,024	14.2
GERMANY (March 31, 1932):			
Berlin	4,270,000	496,148	11.6
Breslau	616,000	42,489	6.9
Cologne	741,000	66,768	9.0
Dresden	630,000	60,085	9.5
Dortmund	534,000	24,702	4.6
Essen	649,000	29,726	4.6
Frankfort-on-Main	615,000	64,927	10.6
Hamburg-Altona	1,595,000	169,670	10.6
Leipzig	716,000	67,993	9.5
Munich	697,000	75,784	10.9
GREAT BRITAIN AND NO. IRELAND (March 31, 1932):			
Belfast	415,000	16,717	4.0
Birmingham	1,178,000	53,885	4.6
Bristol	412,000	19.524	4.7
Edinburgh	441,000	29,599	6.7
Glasgow	1,180,000	57,028	4.8
Leeds	508,000	22,488	4.4
Liverpool	1,184,000	56,487	4.8
London	8,900,000	769,928	8.7
Manchester	1,094,000	61,889	5.7
Newcastle	469,000	18,811	4.0
Sheffield	514,000	19,015	3.7
HAWAII:			
Honolulu	140,000	17,516	12.5
HUNGARY:			
Budapest	1,012,000	77,055	7.6
Szeged	136,000	2,381	1.8

TELEPHONE DEVELOPMENT OF LARGE CITIES (Concluded)

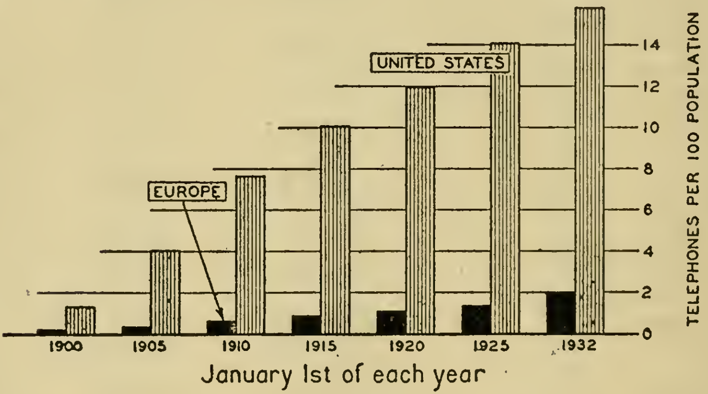
January 1, 1932

Country and City (or Exchange Area)	Estimated Population (City or Exchange Area)	Number of Telephones	Telephones per 100 Population
IRISH FREE STATE:			
Dublin (March 31, 1932)	415,000	17,132	4.1
ITALY:			
Genoa	650,000	29,153	4.5
Milan	990,000	78,999	8.0
Rome	945,000	65,173	6.9
JAPAN (March 31, 1932):			
Kobe	804,000	29,849	3.7
Kyoto	977,000	36,729	3.8
Nagoya	934,000	29,238	3.1
Osaka	2,520,000	104,902	4.2
Tokio	3,425,000	155,219	4.5
LATVIA (March 31, 1932):			
Riga	395,000	19,334	4.9
MEXICO:			
Mexico City	1,000,000	50,390	5.0
NETHERLANDS:			
Amsterdam	766,000	52,487	6.9
Haarlem	152,000	11,227	7.4
Rotterdam	605,000	41,096	6.8
The Hague	487,000	46,126	9.5
NEW ZEALAND (March 31, 1932):			
Auckland	207,000	21,579	10.4
NORWAY (June 30, 1931):			
Oslo	250,000	48,524	19.4
PHILIPPINE ISLANDS:			
Manila	385,000	17,631	4.6
POLAND:			
Lodz	824,000	14,330	1.7
Warsaw	1,178,000	57,361	4.9
PORTUGAL:			
Lisbon	595,000	23,318	3.9
ROUMANIA (January 1, 1931):			
Bucharest	630,000	17,103	2.7
RUSSIA (October 1, 1931):			
Leningrad	2,235,000	70,419	3.2
Moscow	2,780,000	90,561	3.3
SPAIN:			
Barcelona	850,000	41,605	4.9
Madrid	850,000	46,851	5.5
SWEDEN:			
Gothenburg	248,000	39,545	15.9
Malmö	130,000	19,419	14.9
Stockholm	436,000	137,999	31.7
SWITZERLAND:			
Basel	148,000	25,456	17.2
Berne	112,000	20,106	18.0
Geneva	144,000	24,079	16.7
Zurich	254,000	46,963	18.5
UNITED STATES:*			
New York	7,100,000	1,753,380	24.7
Chicago	3,488,000	939,481	26.9
Los Angeles	1,345,000	398,861	29.7
Pittsburgh	1,000,000	225,234	22.5
Total 9 cities over 1,000,000 Population	20,827,000	4,988,907	24.0
Milwaukee	737,600	156,408	21.2
San Francisco	665,000	260,204	39.1
Washington	582,500	194,653	33.4
Minneapolis	508,000	131,914	26.0
Total 11 cities with 500,000 to 1,000,000 Population	7,018,900	1,574,916	22.4
Seattle	408,200	124,617	30.5
Denver	293,200	92,547	31.6
Hartford	237,700	58,361	24.5
Omaha	231,200	66,413	28.7
Total 31 cities with 200,000 to 500,000 Population	9,149,200	1,912,794	20.9
Total 51 cities with more than 200,000 Population	36,995,100	8,476,617	22.9

* There are shown, for purposes of comparison with cities in other countries, the total development of all cities in the United States in certain population groups, and the development of certain representa-

average development for 51 American cities exceeds that of any single large foreign city. Chicago had 939,481 telephones, a development of 26.9; New York had 1,753,380 telephones, or 24.7 instruments per 100 of its inhabitants. The number of telephones in Chicago, however, represents less than five per cent of all the telephones in the United States, and New York has less than nine per cent of the total. In the case of the capital cities of London and Paris, however, it will be found that the number of telephones constitutes a far greater proportion of the total number in the country as a whole. Thus, London, with its 769,928 telephones, had 37 per cent of all the instruments in Great Britain; while Paris, with 426,024 telephones, had 34 per cent of all the instruments in France. Similarly, more than one-fourth of all the telephones in Germany were concentrated in the four cities of Berlin, Hamburg-Altona, Leipzig and Munich.

TELEPHONE DEVELOPMENT
IN THE UNITED STATES AND EUROPE



The comparative telephone development of the United States and Europe at various dates since 1900 is shown on the accompanying chart. It is interesting to note that the telephone development of Europe on January 1, 1932, was approximately the same as that of the United States about thirty years ago.

Notes on Recent Occurrences

OVERSEAS SERVICE EXTENDED TO GUATEMALA, INDIA, NICARAGUA AND S. S. *BERENGARIA*

GUATEMALA, India, Nicaragua and the S. S. *Berengaria* were brought within speaking distance of all Bell and Bell-connecting telephones in the United States, Canada, Cuba and Mexico by recent extensions of overseas telephone service.

An exchange of greetings between government and telephone officials of Guatemala and the United States opened service between those countries on April 17. The cost of a three-minute conversation between New York and Guatemala City is $21. Guatemala is reached by a short-wave radio telephone circuit between stations of the Tropical Radio Telegraph Company at Guatemala City and stations of the American Telephone and Telegraph Company at Miami, linked with the Bell System network.

Regular telephone communication between the United States and Bombay and Poona in India began on May 9 through the co-operation of the American Telephone and Telegraph Company and the British Post Office, linking one of the transatlantic radio telephone channels between the United States and England with a short wave channel connecting London and radio telephone stations near Bombay. A three-minute conversation between New York and Bombay or Poona costs $45, with $15 for each additional minute.

Service between the United States and Nicaragua began on June 7 through the co-operation of the American Telephone and Telegraph Company and the Tropical Radio Telegraph Company. The service was inaugurated by conversations between government officials of the two countries. A three-minute conversation between New York and any point in Nicaragua costs $21, with $7 for each additional minute.

Prime Minister J. Ramsay MacDonald of Great Britain, aboard the steamship *Berengaria* several hundred miles out at sea, inaugurated regular telephone service between the liner and North American telephones on April 20, when he spoke with his country's Ambassador, Sir Ronald Lindsay, who was at the British Embassy at Washington, D. C. The *Berengaria* is the nineteenth liner to have ship-to-shore service with the United States.

PRESENTATION OF THE JOHN J. CARTY MEDAL AND AWARD

WHEN General John J. Carty retired from active service on July 1, 1930, after more than fifty years of service in the Bell System, the Directors of the American Telephone and Telegraph Company established in the National Academy of Sciences a gold medal and award in his honor and bearing his name. At the same time his immediate associates provided the design of the medal and the necessary dies to be used by the United States Mint in striking the medal.

These acts were in recognition of General Carty's outstanding achievements, not only in the field of electrical communication, but likewise in the whole field of applying science to the benefit of mankind.

Under the provisions of the Deed of Gift, the National Academy of Sciences is empowered to make an award not oftener than once in two years, without restriction of race, nationality, sex or field of science, to anyone who in its judgment has done particularly outstanding work in the promotion of scientific research or application. The Deed of Gift also provides that, in addition to the medal, the entire net income from the medal fund since the last preceding award shall be given to the medalist.

Acting under the Deed of Gift, the National Academy of Sciences appointed a Carty Medal Committee, which, in due course, recommended that, in their judgment, no more fitting candidate could be selected for the first award of the medal than General Carty himself. This recommendation of the Committee was unanimously approved by the National Academy of Sciences last November, and arrangements were made for a presentation of the medal to General Carty at the annual meeting of the Academy in Washington at the end of April, 1933.

General Carty's untimely death in December made necessary a change in these plans, and the Academy then decided to present the medal posthumously. This altered program was carried out, and the medal and award were presented at the annual dinner of the Academy on April 25, 1933. The case for the presentation of the medal to General Carty was stated by Dr. Frank B. Jewett, the presentation was made by Dr. W. W. Campbell, President of the Academy, and the medal and award were received by General Carty's son, Dr. John R. Carty, on behalf of his mother, whose health did not permit her to be present. A replica of the medal in bronze is in the Historical Museum in the Headquarters Building of the American Telephone and Telegraph Company.

MESSRS. GHERARDI AND IVES ELECTED TO NATIONAL ACADEMY OF SCIENCES

AT THE annual business meeting of the National Academy of Sciences in Washington on April 26, 1933, Mr. Bancroft Gherardi, Vice President and Chief Engineer of the American Telephone and Telegraph Company, and Dr. Herbert E. Ives of Bell Telephone Laboratories, were elected to membership. Mr. Gherardi was proposed by the Section of Engineering and Dr. Ives by the Section of Physics. With their election, the Bell System is now represented in the Academy by four men, Dr. Jewett and Dr. Davisson of Bell Telephone Laboratories already being members of the Academy. The late General J. J. Carty was also a member of the Academy.

The National Academy of Sciences was established by act of Congress during President Lincoln's administration, and is the only nationally chartered scientific organization in the United States. Its present membership of about 250 comprises leaders from all fields of pure and applied science. By statutory limitation, not more than fifteen men or women can be elected to membership in any one year.

ACADEMIC HONORS FOR BELL SYSTEM MEN

BANCROFT GHERARDI, Vice President and Chief Engineer of the American Telephone and Telegraph Company, has received the honorary degree of Doctor of Engineering from the Polytechnic Institute of Brooklyn, New York.

William H. Meese, Vice President and Works Manager of the Western Electric Company's Point Breeze Works at Baltimore, has received the honorary degree of Doctor of Laws from Washington College, Chestertown, Maryland.

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OCTOBER, 1933

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The Engineer and a Century of Progress

Editor's Note:

The following address by Mr. H. P. Charlesworth, Assistant Chief Engineer of the American Telephone and Telegraph Company, was delivered by him on June 26, 1933, as President of the American Institute of Electrical Engineers, at its summer convention, which was held at Chicago, Illinois.

WE ARE gathered here at Chicago this week not only to participate in our usual summer convention, but also in a coming together of the greatest conclave of engineers of our own and other professions that ever has assembled or that may assemble again for many years to come. The occasion of this assembly is in a sense a celebration of a century of progress so admirably portrayed by the wonderful monument to human advancement that has been spread out along the shores of Lake Michigan, through the courageous efforts of the people of Chicago in honor of the centennial of the incorporation of Chicago as a village.

It is an interesting coincidence to those of us who are electrical engineers that electrical science is approximately the same age of the City of Chicago. It was just 100 years ago that Faraday in England, Henry in the United States, and other great scientists building upon the work of Ohm, Ampere, Oersted, and others, were completing the foundation of fundamental principles upon which have been erected the vast fabrics of applied arts and industries which are the concern of the electrical engineer today.

The wonderful exhibition here in Chicago, aptly termed "A Century of Progress," presents the progress of man during the past century in particular. It is most fitting, therefore, that we should find here gathered together engineers and scientists from all parts of the world, especially when we recall the great contributions to this progress made by them individually and collectively. What is more important, however, is that we are, I believe, consciously or unconsciously, carefully weighing the progress which has already been made to the end that we may gain courage to carry us through our present difficulties and inspiration to plan for still greater achievements in the future, not alone in the material things of life, but also in the broader aspects of human advancement.

During the past 50 centuries or so of historical time and throughout the unnumbered centuries that preceded them, the story of mankind has been primarily a struggle for existence. We need go back only a comparatively few years to observe the scarcity of machines and mechanical aids that were available. Indeed, using his hands alone, the average man had to work from early morning often far into the night merely to provide food, clothing, and shelter. Today, this average individual has material comforts that not so long ago would have been the envy of the favored few.

Surrounded as we are with safe and comfortable modes of living, it is difficult to appreciate adequately the status of mankind during that earlier period. Yet, it is essential that we should vividly picture his trying existence if we are fully to appreciate the degree of our progress and the relative unimportance of some of the hardships resulting from our present difficulties. To draw our comparison properly we must study carefully the life of the masses of people in the earlier centuries, and thus secure some picture of the hardships of living, often in isolation with no ready means of transportation or communication, with heat and shelter depending upon the crudest facilities, sustenance often on single crops subject to the vicissitudes of the weather; with life as a whole frequently controlled by the whims of a despot or warring factions. An existence, therefore, for the average man much like that character in Grecian mythology who, in the Lower Regions, was condemned eternally to roll the stone of forlorn hope up the steeps of despair.

How different the picture as we contrast these earlier conditions with our present state of civilization, and contemplate what has been accomplished in improving our existence and removing drudgery from our daily tasks. We cannot fail to recognize, therefore, that, during the past century in particular, science more than any other single factor has influenced human affairs and added to the opportunities for a broader and happier life.

In spite of this evidence on every hand of real benefit which mankind has secured through the progress of science and engineering, we occasionally find arising in some quarters, and particularly under the difficult times through which we have passed, a fear of science and its effect upon us. We hear that there should perhaps be a holiday in the field of research and in the new applications of science. To any intelligent and thoughtful person it is evident how foolish and vain both these points of view are and I think we may view with satisfaction the fact that we have been in no way influenced by these false premises, but rather that we have adhered steadfastly to the sound principles upon which our progress has been based.

We know full well that we cannot set up arbitrary or effective bars against man's curiosity of the unknown, or the researches which follow from that curiosity, nor can we long delay the introduction of things which man believes to be valuable additions to his social life. Furthermore, from our own experience, we have seen ample evidence, and there are constantly spread out before us many examples of the fact that such advances should not be retarded but on the contrary, are the very instrumentalities upon which our future progress must be based.

It is true, of course, that we have been passing through difficult times and have experienced during the past 20 years two of our greatest catastrophes, namely the World War and the present world-wide industrial depression. We find ourselves today in a world which has experienced undue privation and want, full of anxiety and uncertainty, and here and there in actual discord. Perhaps it is not surprising, therefore, that some have questioned: "Has this really been a century of progress?" However, I am sure that there is ample proof that the present crisis from which we are emerging cannot wipe out the experience of a century of lessons or the real measure of our progress which is to be derived therefrom.

Progress is defined as "a moving or going forward, an advance toward better or ideal knowledge or condition or that conceived of as better." In other words progress is an advance toward a goal and in order to determine whether or not progress is being made, it is necessary first to define our goal. I believe that there is general agreement that the goal toward which mankind is striving is an increase in human happiness in its broadest sense. Our goal remains poorly defined, however, until we express in some more concrete way the conditions that are expected to lead to the greatest happiness of all mankind. One would be bold, indeed, to attempt a detailed definition of this matter which has to do with so many factors concerning the whole relationship of man to man and of man to his environment. May I venture, however, the suggestion that this involves primarily three things: first, the easy provision of the necessities of life, including among necessities the things commonly used by the social group; second, a sense of security obtained by minimizing the number and extent of those catastrophes which destroy or disrupt human life; and third, the capacity and opportunity through leisure for appreciation of the world and of the people and things in it, with the development of character and culture.

Now I think, particularly in view of the history of recent years, it must be admitted that the progress made in the last century, as thus broadly defined, has by no means kept pace with technological advances. The applications of science have opened opportunities for increased comforts, for decreasing the number of hours of labor required for producing the necessities of life, and for providing the surplus productivity which should lead to security and give men the leisure in which to develop and exercise the capacity of appreciating the world in which they live. As I see it, the difficulty is that these rapid developments in the material things of life naturally require the continuous adjustment of society, and up to the present time social reorganization has not kept pace with our material advances.

This is not a condition of recent years alone. It appears to have been a chronic condition of society. It involves many factors, among which is a lack of appreciation of what science is accomplishing for mankind. This can be illustrated in many ways, as for example, by the opposition with which many important advances have been greeted, particularly in earlier days. Developments that are evidently of great benefit to mankind, in one way or another, repeatedly have been opposed even by those who should be in the best position to realize the ultimate advantages of the new device. We smile when we read a 17th century protest against the "large coaches" which were about to be placed in service between London and York and which would carry as many as 18 passengers and would make the trip of 175 miles in 4 or 5 days. We note "the vast amount of employment those eighteen persons would give to grooms, farriers, innkeepers, hostlers, saddlers, etc., if each were to ride his own horse instead of adopting the revolutionary practice of clubbing for a common conveyance." Again, we recall with interest, that when attempts were made to introduce the saw mill in England they were opposed violently; yet we know that soon it became recognized that through its use human effort could be conserved, new products looking toward human comfort could be provided at reasonable cost, and through the diversity of the mill the opportunity for employment actually be increased. And so might be cited similar examples in every phase of our industrial progress. Fortunately, with a growing understanding of what science is accomplishing there has been less opposition and material progress has been possible but other serious problems have presented themselves.

While, therefore, any well considered study of our advancement particularly in the past century, cannot but lead to the conclusion that science and invention have been the life blood of our progress, it must be recognized that during this period science has injected into human life a multitude of factors with which our forefathers did not have to deal, but with which we and our successors must reckon. The sooner we approach a better understanding of these factors and how to deal with them in an intelligent and forward-looking manner, the sooner will we make for real progress in the broader problems that confront us. In other words, we must recognize and understand these new factors so as to weave them properly into our social structure. The application of science is placing in the hands of individuals, and of nations, vast powers for good or evil, far greater than those of any earlier century. Hence, the pace of humanity, in any direction in which it is advancing, constantly quickens. With this has come an increase in the complexity of social relationship brought about through a closer and closer interdependence of the different parts of the world.

All this, it seems to me, must have an important bearing on the work of the engineer. In the earlier days, we find the scientist and the engineer working in a large measure in isolation, and working, in turn, on the many phases of a problem often not too well defined. As time progressed, and to an increasing extent during the past century, we have found large groups coming into existence for the study and furtherance of research and engineering. Today the modern research or engineering problem is being approached by a group attack; that is, the problem is being defined as far as practicable and specialists in their respective fields are being assigned to its various parts. And so we find the engineer depending to a greater and greater extent upon his fellows, not only in his own profession, but also in the other branches of the arts and sciences. Not only is this true in industry itself, but in order that their work may be carried on effectively and to the end that they may be qualified and keep in step with the rapid progress experienced particularly during the last half of the past century, engineers have had a greater and greater tendency to come together into great organizations such as our own society. In more recent years we find a growing recognition that not only must we be banded together in our own profession, but there must be a growing tie between engineers generally. Thus came into being the American Engineering Council and similar organizations which already have done so much for the profession and for the nation.

As I view the situation, however, these activities alone will not be sufficient. We must be prepared to take an even greater part in public problems and to assist in the affairs of society generally through daily contacts as citizens of our communities and of the nation. In some respects the engineer seems to me to be in a position to make a special contribution. He should have a clear perception of the nature of the revolutionary technical changes through which the world is going, of their effect on human life and on the social problem. Furthermore, if he has, as he should have from his training, developed the scientific habit of thought, that is, approaching the problem from the standpoint of determining the facts and reasoning from those facts to the conclusions, he should be able to bring something of real value to bear upon the problems of social reorganization. He has come to realize through years in the hard school of experience that things cannot be taken for granted, that the best way of doing a thing today may be far from the best way of doing it tomorrow.

The social problem involves all the people and its solution requires the continuous effort of men of all vocations who can contribute to it. As I see it, therefore, in embarking upon our work of the next century we should find the engineer not only working in closer association with his fellows in the field of science and engineering, but, if he is to prove of greatest usefulness, also developing a closer association with other groups of society. To the extent that we effectively recognize these new responsibilities and opportunities, we will, I am sure, make still greater contributions to the benefit of mankind. As we enter upon these broad responsibilities of our profession, we should proceed with characteristic purposefulness, always remembering, however, that in many cases our greatest help can be by contributions within the limit of our knowledge and experience, rather than attempting alone to direct in fields where considerations beyond the scope of engineering must weigh heavily in the final decisions.

Opportunities for constructive help present themselves on every hand, particularly in times like the present. Basically there is need from the very beginning for a better understanding of the effects and results of science and engineering on our daily existence. We who have made this our life work are, it seems to me, in the best position to foster a real understanding of what science is and what it reasonably can be expected to accomplish or not accomplish and the methods by which those results can be employed most effectively. This greater knowledge is necessary not only to scientists and engineers, but also to those who make up society generally. It seems to me, therefore, that this becomes one of our fundamental responsibilities.

To appreciate the importance of the broader understanding, we have but to look about us and consider what has been going on in many fields where a full recognition of the effects of science has not been taken into account. Despite the rapid progress that has been made and the marked effect which new developments, that can often be foreseen, may have on products or procedures, we often have seen planning and financing carried on year after year without a recognition of the effects which these rapid changes have on industries or individual projects in question. In many industries based on science it has been found to be as important to know about their research or engineering organizations and of the attitude of the management toward these activities as it is to know about their financial status. Again, in the case of agriculture for example, we often have seen efforts being directed toward greater and greater production of a given product of the soil when overproduction as a whole already was in evidence. Too many great undertakings have been carried forward without reflecting adequate advance planning; and conversely, other projects that have had a full measure of such consideration devoted to them stand out as marked examples of the value and importance of such an approach.

Not only can the engineer be helpful in those matters in which his profession is directly concerned but also in the broad problems which today confront our nation and the world. Many of these do not involve engineering matters, but nevertheless do require the same careful planning and foresight which enter into our daily engineering undertakings. If, in our individual capacities as good citizens, we can apply some of this attitude of mind and instill in others the importance of this approach to some of these problems, I am confident we can make contributions of great value in these broader fields as we have in the fields of science and engineering. The need for some such approach to the problem is all too evident when we consider some of the spectacular proposals which, although based on such an utter disregard of fundamental facts, are submitted from time to time as cure-alls for the troubles of the world.

Gradually through a general understanding of science and the application of the principles of straight thinking to some of our broader problems, we should be able to make progress in the field of social organization as man has in the material aspects of human advancement. That we should be able to make this broader progress, I believe there can be no doubt, for, in the recent words of President Roosevelt, "Certainly the human intelligence that has accomplished the industrial and cultural results displayed at your Exposition need not fall short of devising methods that will insure against another perilous approach to collapse such as that from which we are now emerging. . . . The advance of science and the evolution of humanity and charity made it known to us that whatever is the result of human agency is capable of correction by human intelligence. Who is there of so little faith as to believe that man is so limited that he will not find a remedy for the industrial ills that periodically make the world shiver with doubt and terror?"

As I have indicated already, there is opportunity for the engineer to make substantial contribution to the advance of this side of our social welfare. That he may prepare himself to take this broader responsibility, he must, as I see it, adjust himself to an even broader viewpoint, and acquire a more intimate knowledge of the economic forces and social problems of our daily life, than he has in the past. That he will be able to do so I have no doubt. As our engineering educators so wisely have appreciated, this trend also must be fully reflected in the training of the younger men who are to become the leaders in the future. If we thus can make progress toward a better equilibrium between our technical and social knowledge and reflect its effect upon the advancement of society generally, then I believe we may look with real hopefulness to a nearer approach to our goal of progress as previously interpreted.

The development of culture requires leisure from the struggle for existence, and such leisure gives us opportunity in turn for the development of things of the mind and of the spirit. At various times in history, periods of culture have been experienced. Often, however, this has come about through opportunity for leisure for the few by imposing drudgery on the many. Can we not look upon science, however, coupled with a proper utilization of the products of science, as the medium through which we now may secure a reasonable degree of leisure for the greatest number? With this, no doubt, comes the added advantage of tending not toward lack of initiative coupled with that leisure, but toward creation of leisure through initiative itself. May we not then feel that we have really built on a firm foundation for progress?

If we of the engineering profession, working in full cooperation with all other groups of society, can contribute in some measure to this further progress of mankind, we may justly take pride in the service we render and feel with satisfaction that again we have widened our sphere of social responsibility. Society, I believe, has come to expect of us a devotion to the truth wherever the facts may lead us and an aim toward unbiased judgment. We should safeguard this trust which is placed in us and continue our efforts along those channels of endeavor wherein we may be of greatest help, and in those fields where we are best qualified to advise, to the end that we always may be of greatest service to society as a whole. If we can so govern our efforts in the period ahead and broaden our knowledge and approach to a better molding of the social and material sides of life, we will have done our part in making the world a better and happier place for our fellowmen and will reap the satisfaction that comes to all of us from worthwhile endeavor.

H. P. CHARLESWORTH

The Vacuum Tube in Telephone Communication

MR. BROWN of New York, as he talks with Mr. Smith of Los Angeles, is no longer surprised that he can talk with ease over such a distance but would, no doubt, express astonishment if he were told that some 200 vacuum tubes were directly involved in his conversation. The circuit over which he talks would probably be made up of four wires in cable between New York and St. Louis and a carrier circuit on open wire from St. Louis to Los Angeles. Many of the 200 vacuum tubes are distributed at intervals along the line in telephone or carrier repeaters where they serve to amplify the speech currents after they have become attenuated by the line. Other vacuum tubes, at the beginning of the carrier part of the circuit, serve to step up the pitch or frequency of the voice currents several octaves. Still others at the end of the carrier link step the frequency of the currents down again to their natural pitch. This permits the line to carry at the same time other telephone conversations, each of which is kept distinguishable from the others by being transposed in frequency by vacuum tubes to its own particular pitch or frequency assignment on the line.

Besides the vacuum tubes thus directly involved in the transmission of the speech there are others which are essential parts of the signaling arrangements used by the operators at the two ends of the circuits to signal each other, and of the oscillators and transmission measuring devices by means of which such a complex thing as a transcontinental circuit is kept functioning properly.

The above example illustrates the important part which the vacuum tube has played in extending the range of the human voice. The use of the vacuum tube is not confined to very long circuits, however, for substantially all telephone circuits more than 100 miles or so in length, and some much shorter even than this, employ vacuum tubes in telephone repeaters or other apparatus.

The growth in importance of the vacuum tube has brought about a far-reaching change in the telephone engineering art. The vacuum tube has made available an important new tool and has brought in many associated developments with which every telephone transmission engineer must be familiar. He must know a great deal about the theory entering into the design of telephone repeaters, carrier apparatus, etc. He must be conversant with such related things as electrical filter design, and the design and manufacture of toll cables to obtain uniform characteristics and low crosstalk. He must know how to lay out circuits so as most effectively to use vacuum tube apparatus having in mind the economies involved and the overall performance.

The trends in the design of the wire plant itself have been greatly influenced by the vacuum tube. In the early part of this century the only method known to extend telephone communication to longer and longer distances was to reduce the attenuation of the lines by using larger and larger wire conductors and later by loading them heavily with inductance coils. The possibilities in these directions were soon exhausted and some sort of means for amplifying the speech currents was urgently needed. For a while a limited use was made of "mechanical repeaters," whose amplifying units consisted essentially of a telephone receiver talking into a transmitter—in actual fact a "repeater." The advent of the vacuum tube opened up new possibilities, however, and now because of the use of frequent vacuum tube repeater stations along the lines, it is possible to construct the wire plant more cheaply by using smaller gauge wires, and, where the volume of traffic warrants it, by placing many wires in the same lead sheath of a toll cable. Moreover, it is the present custom to load the wires only lightly with loading coils or in the case of open-wire lines not to load them at all. Enough has been said to show that much of the modern art of long distance telephony is built around and is dependent upon the vacuum tube.

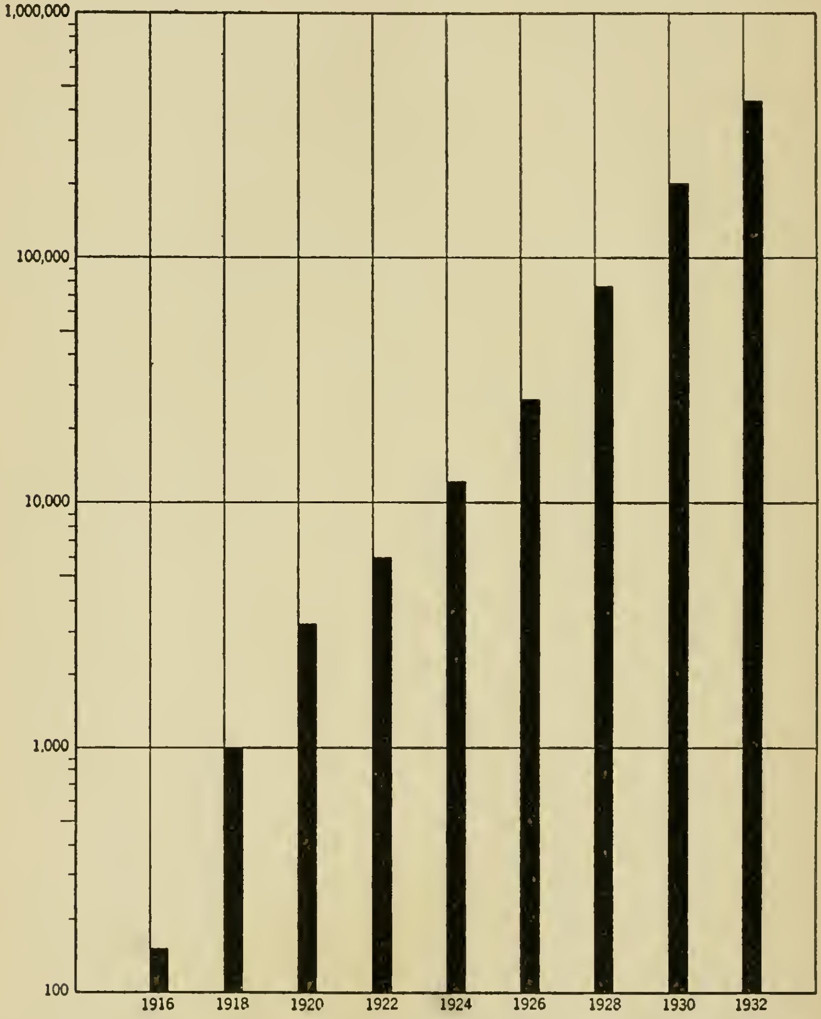

Figure 1. Growth in Number of Vacuum Tubes Installed in Bell System Plant.

Vacuum tubes were first used in regular commercial service in the telephone plant about the beginning of 1914. Their number increased rapidly, more than doubling every two years, until at the beginning of 1932 there were over 350,000 in service in the Bell System. This growth is illustrated graphically in Fig. 1. The tubes are divided among the various types of plant about as follows:

Telephone repeaters	65	per	cent
Ringers	10	"	"
Carrier telephone and telegraph systems	20	"	"
Program repeaters, echo suppressors, transmission testing equipment, etc.	5	"	"

These are the principal classifications based on the quantities of tubes in service. For completeness, however, mention could be made of a number of other types of apparatus which employ tubes although not in sufficient quantities to loom large in the totals. These include public address systems, the amplifiers used in the time-of-day service in the larger cities, the telephotograph apparatus and the radio stations forming the American terminals of the radio links with Europe, South America, Central America, Bermuda, Hawaii, the Philippines and ships at sea.

The vacuum tubes used in these various types of apparatus are of all sizes ranging from the miniature "peanut" tube with a power output rating of about one-hundredth of a watt to the large water-cooled tubes with power output ratings of many thousands of watts. About 90 per cent, however, of all of the vacuum tubes in the telephone plant are of the two types familiarly known to telephone engineers as L and V tubes. These two types account for nearly all of the tubes used in the telephone repeaters, carrier systems and ringers. Although many improvements have been made from time to time which have decreased their power consumption, and increased their uniformity and average life these general types have been continued from the earliest days of the commercial application of vacuum tubes to telephony. The 1933 models of these tubes are illustrated in the accompanying pictures.

Long after their introduction into telephony, vacuum tubes have in recent years been popularized by their widespread use

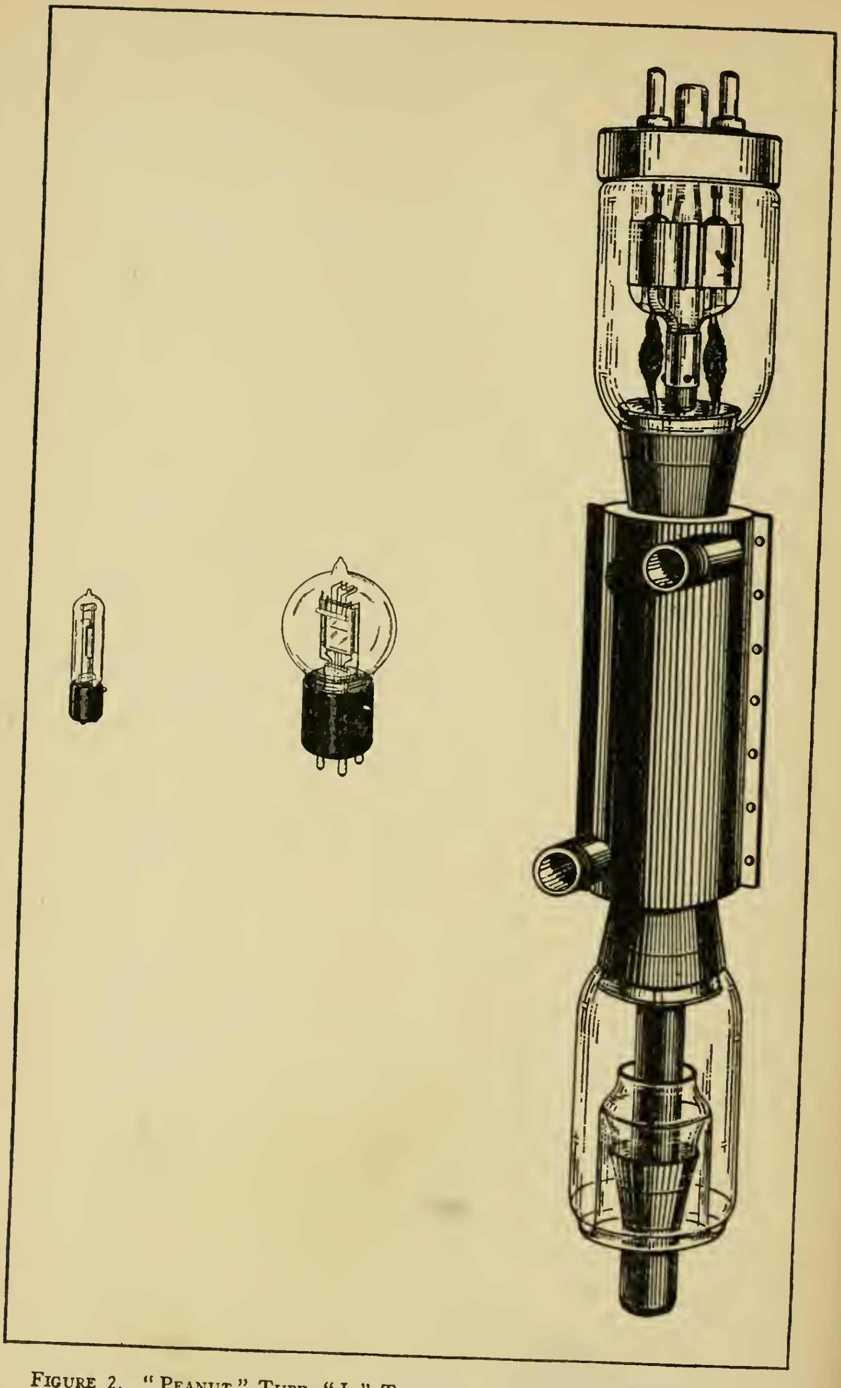

Figure 2. "Peanut" Tube, "L" Tube and 10 Kilowatt Water-cooled Tube Shown to Same Scale.

in radio broadcast receiving sets. Nearly everyone is now familiar at least with the appearance of a vacuum tube. Very many have some degree of technical appreciation of the manner in which a vacuum tube may be used as a rectifier to transform alternating to direct currents, as an oscillator to transform direct to alternating currents, as an amplifier to amplify either direct or alternating current, or as a modulator, demodulator or detector to modify the frequency of an electrical current. It is, therefore, not important to discuss in a technical manner the way in which a vacuum tube works.

We are interested, however, in noting the special problems which distinguish the application of vacuum tubes to telephony from other applications such as radio. In serving these different applications, the vacuum tube finds telephony the harder taskmaster. To give satisfactory service, it must meet stringent requirements in regard to long life, uniformity, stability and freedom from distortion of the voice currents. In a radio set, the vacuum tubes may depart considerably from their ideal performance before the listener becomes aware that something is wrong, for the human ear is too coarse an instrument with which to detect even fairly large changes in volume or quality. In a telephone circuit, however, so many tubes may be in tandem that their individual performance must be almost perfect if the cumulative effects of the distortions and instabilities which they introduce are not to be excessive.

For example, in the New York–Los Angeles circuit referred to earlier, there are employed over 200 vacuum tubes; about one-half of these are used when the man in New York speaks to the man in Los Angeles and the other half are called into play when the Los Angeles man replies. Altogether there are, say, 25 times as many tubes in the circuit as in a good radio set. The failure of any one of these tubes would interrupt the conversation. The likelihood of burning out or sudden failure from any cause should therefore be only one twenty-fifth as great for each of the tubes used on the telephone circuit as for each of those in the radio set, if the circuit is to be at least as reliable as a radio set. Of course, an effort is made to avoid service failures of the tubes on the telephone circuit by regular tests and inspections, but long tube life is nevertheless of vital importance to this end. For this reason the vacuum tubes for telephone use are designed to have average lives which are much longer than those usually considered necessary for other services. The present L and V tubes have average lives in the Bell System Plant of about 18,000 and

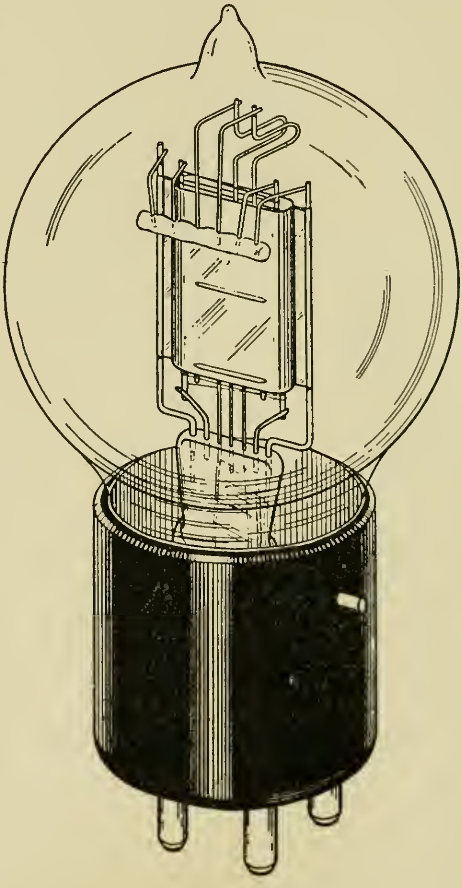

Figure 3. 101 F Vacuum (Type "L") Tube.

70,000 hours (two and eight years) continuous use, respectively, and this in spite of very rigid requirements for determining when a tube must be replaced. The average life of the tubes used in radio receiving sets is only a small fraction of these figures, taking into account that radio sets are used only a part of each day.

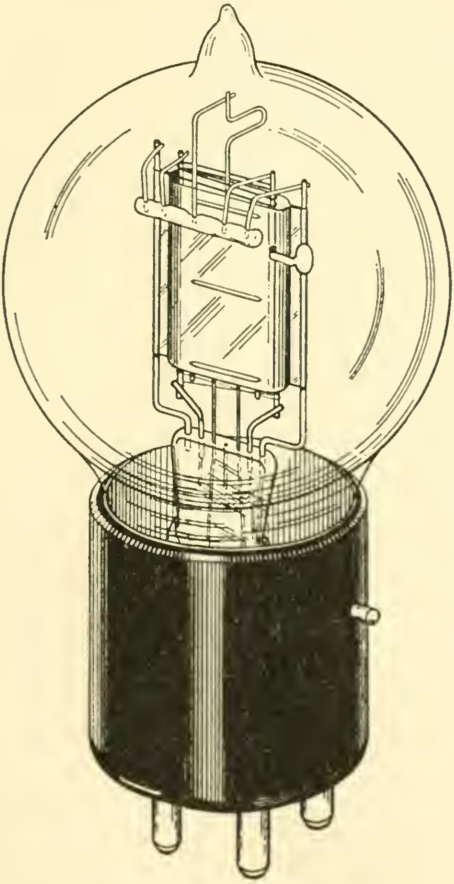

Figure 4. 102 F Vacuum (Type "V") Tube.

Not only is long life desirable but the amplification of the tubes must be very stable. It must not fluctuate greatly when the batteries which supply the power to the tubes vary, or for any other reason. The importance of this is evident when it is realized that the overall attenuation of a long circuit is a small margin between two very large quantities—the attenuation of the bare wires and the total amplification supplied by the vacuum tube repeaters. The New York–St. Louis four-wire cable circuit, which forms part of the circuit between New York and Los Angeles referred to earlier, is a little over 1000 miles in length. The attenuation of a 19-gauge cable pair of this length would be enormous if not equipped with telephone repeaters—about 500 decibels in engineering terms. This amount of attenuation is beyond comprehension. It has been computed that if the whole amount of energy radiated by the sun could be converted into an electrical current of audible frequency and transmitted into the cable pair at New York, not a sound would be heard in a telephone receiver in St. Louis, even though the cable pair could withstand the abuse. Yet by placing every 50 miles along this circuit telephone repeaters having a total combined amplification almost equal to the attenuation of the bare wires, the effective overall attenuation of the circuit is reduced to only a few decibels so that a whisper in New York is made audible in St. Louis. It is evident that if the overall result is to be stable, the total amplification must be even more stable. The working margin is not only small, but it must remain steady within limits which are still smaller if crosstalk, noise, echoes, or repeater overloading are not to impair unduly the use of the circuit. It is obvious that this imposes the requirement of a high degree of stability on each of the vacuum tubes contributing to the total repeater amplification.

Similar considerations apply with regard to the necessity of not permitting the tubes to distort the transmitted voice appreciably. Vacuum tubes not very far short of perfection are evidently needed if as many as a hundred tubes are to have opportunity to affect the voice currents in succession along a circuit without finally distorting the voice so as to make it

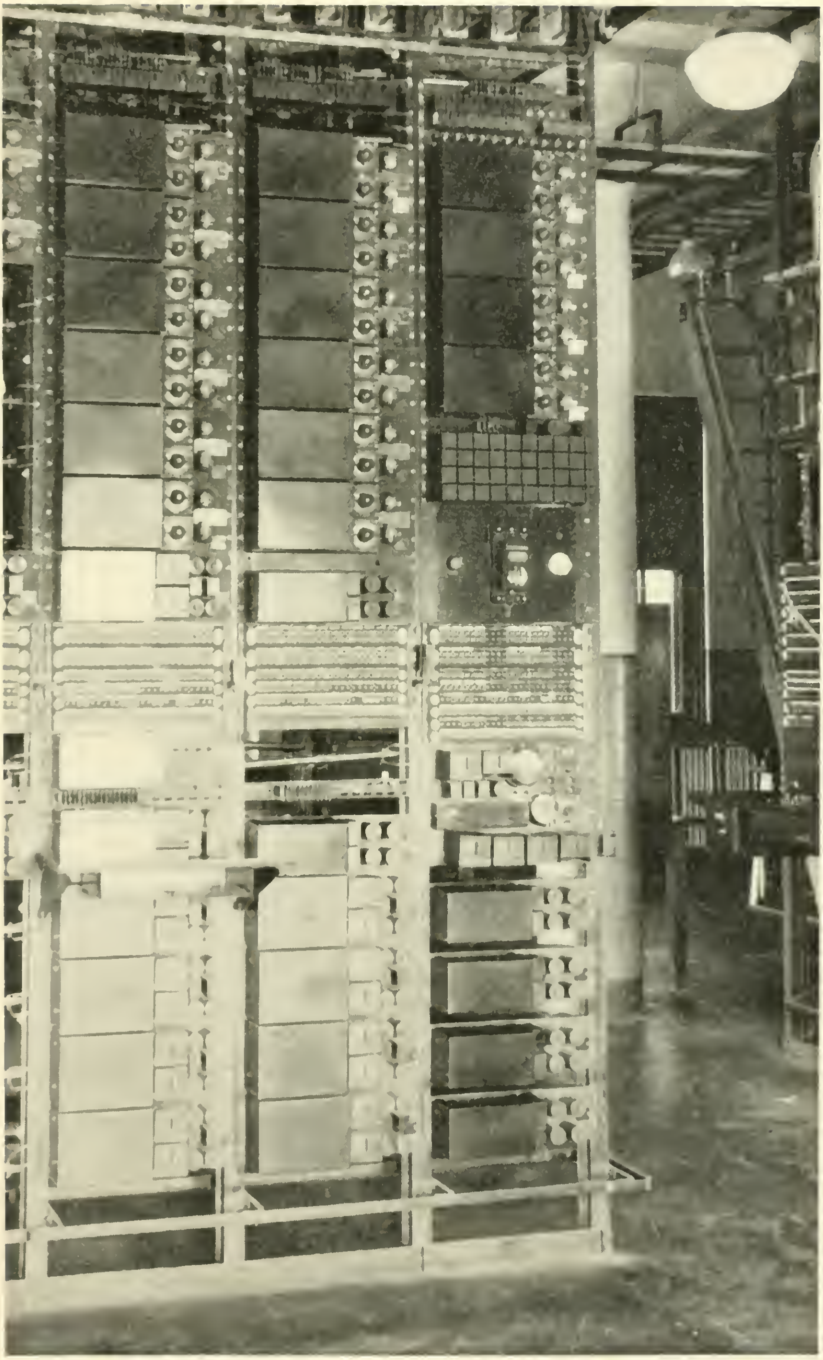

Figure 5. A Group of Two-wire Telephone Repeaters with Accessory Equipment.

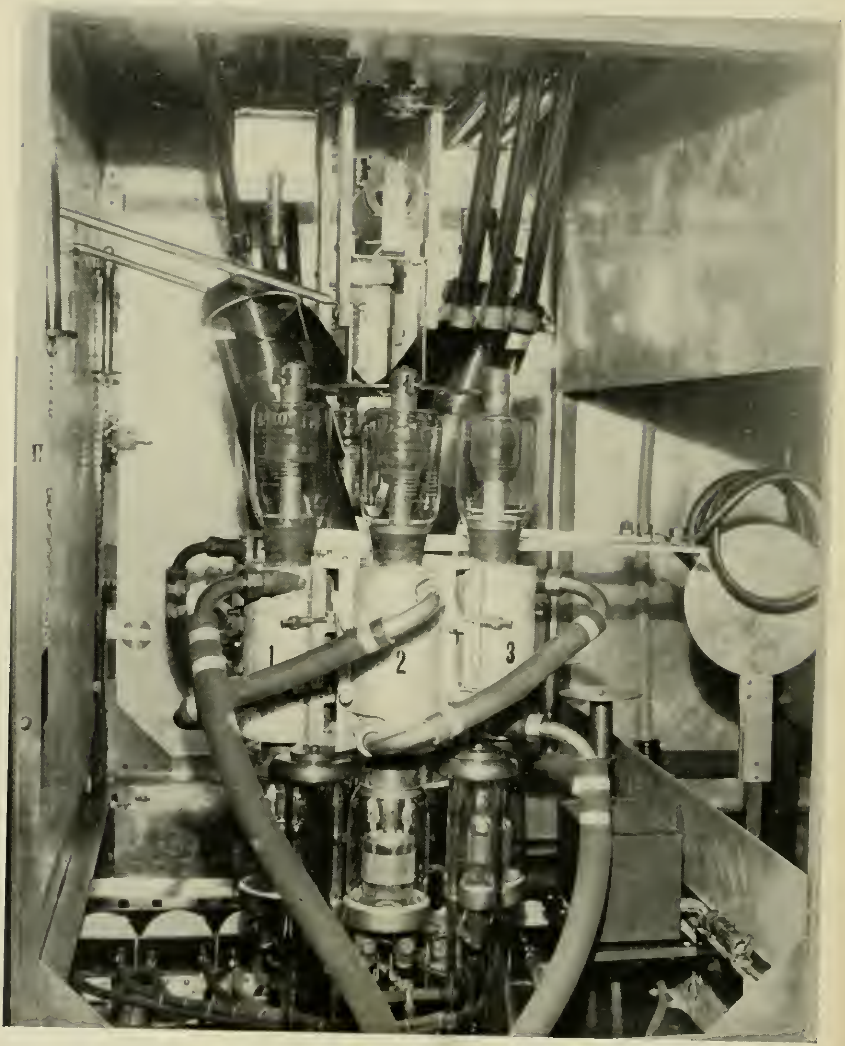

Figure 6. Group of Six 10 Kilowatt Tubes in Short Wave Radio Transmitter at Lawrenceville, N. J.

unrecognizable or unintelligible to the listener. Of course, only a few circuits are as long as the New York–Los Angeles circuit but many of the shorter circuits must be of sufficiently high grade to be used, when needed, as parts of longer built up connections.

As mentioned earlier, the general types of tubes which are most common in telephone plant have existed since the very first. That is, their general electrical characteristics and even their appearance have not greatly changed through the years. In performance and economy of operation, however, the vacuum tubes of today differ as greatly from the tubes of 10 or 15 years ago, as do automobiles of those same respective periods, thanks to the development work which has been carried on by Bell Telephone Laboratories.

The vacuum tubes in use 10 or 15 years ago had average lives of less than one-tenth of the average lives of the present tubes and consumed several times as much power. These tubes, in turn, were almost as great an improvement again over the first tubes of about 1914. The average cost of keeping a vacuum tube socket supplied with tubes and with power would be increased about $33 per year if the tubes of 10 or 15 years ago were used in place of the modern tubes, and over $200 per year if the very earliest tubes were used, even when it is assumed that the price of the older tubes is based on present manufacturing costs, rather than the higher costs that prevailed in their day. The growth in the vacuum tube plant has no doubt been partly in response to the improvements which have been made in the tubes, but if it could be imagined that the present size of plant had to be operated with the old time tubes, the operating expense of the Bell System would be increased nearly $12,000,000 per year by the use of the tubes of 10 or 15 years ago, and by a much greater amount by the use of the 1914 tubes.

Looking ahead, it appears evident that the fields of usefulness of the vacuum tube to the telephone are far from exhausted.

Further developments are expected to increase to a still greater extent the economy of operation of the tubes. New types and improved designs are bringing about the possibility of obtaining new results in their use or of obtaining the same results with fewer tubes or simpler circuits. So it will not be surprising if the vacuum tube continues to find increasing application, not only to the problems of long distance telephony, but also to those of the local plant in metropolitan and suburban areas.

D. K. Gannett

The Development of the Western Electric Audiphone

GENERATIONS of music lovers have come away from concerts uplifted by the great chorus of joy in Beethoven's last symphony; but saddened by the knowledge that much of the mighty work remained forever unheard by its creator. Certain it is that the astonishing "mind's ear" which enabled Beethoven to conceive his later compositions never fully compensated him for his loss of hearing. To his dying day he remained pathetically ready to be duped into purchasing the miserable tin funnels and "ear trumpets" that passed for hearing aids a century ago.

Today we know that an ear trumpet would probably have to be built with an opening about twenty feet in diameter in order to admit enough sound to restore Beethoven's hearing, and that such a horn would dissipate almost all of the high pitched sounds before they reached his ear. Fortunately the same researches that have given us this information have given us better means for aiding the hard of hearing. Were Beethoven listening to his Ninth Symphony today, his identity would probably be revealed more by his pugnacious face than by the inconspicuous electrical instrument that enabled him to hear his work.

Investigations along two lines have combined to produce this instrument: development of improved apparatus for electrical communication, and research in speech and hearing. Experience in Bell Telephone Laboratories has shown that the growth of one body of knowledge is almost indispensable to the growth of others. Improved instruments provide new data relating to speech and hearing, and the new data make possible the design of instruments yet further improved. It is altogether logical that the growth thus engendered, with better telephone instruments as its principal fruit, should also afford better equipment for aiding the hard of hearing. There is obviously a close alliance between the problems of enabling those of normal hearing to hear at a great distance, and of enabling the hard of hearing to hear at a short distance. The Laboratories have systematically applied results achieved in the solution of telephone problems to the improvement of instruments for those who hear with difficulty.

The main outlines of our knowledge of hearing have been far harder to come by than they are to tell. It has been found that the normal human ear has tremendous ranges of auditory response. It is sensitive to pitches ranging in their frequency of vibration from about sixteen vibrations per second to about 15,000 vibrations per second. In the most important part of this range, between 500 and 2000 cycles per second, the ear will respond to sounds varying over an extremely wide range of intensities. When the intensities of sounds are measured by the amounts of energy they contain, the range of energies to which the ear is responsive is found to have the almost unbelievable dimensions of one hundred million million to one. This range is bounded at the lower level by the intensity of sound that is just audible, and at the upper by the intensity that causes pain.

When a person is hard of hearing, the lower boundary level is higher, so that sounds must be more intense to be just audible. Ordinarily the amount by which this threshold is raised differs at different pitches and for different people, according to the nature and severity of their hearing ailment. Thus the diminution of a patient's hearing acuity cannot be measured by a single number; a table of numbers, or a diagram of such a table in the form of an "audiogram," must be used, specifying the amounts by which the threshold is raised at various pitches.

This rough description of hearing loss will make clear what is required to aid those who suffer from it. The sounds reaching their ears must be raised in intensity the same amounts as their auditory thresholds. Ideally this amplification should vary, throughout the pitch range, with the patient's audiogram. Since equipment especially designed for each patient would be impracticably bulky and expensive, it is better to design an audiphone that will give the best results in most cases.

The primary object of an audiphone is to amplify the sound reaching the ear of the deafened person by an amount that will offset his loss of hearing, and hence some part of any hearing aid must have this amplifying ability. The simplest and least expensive device suitable for this purpose is a variable-resistance transmitter—fundamentally the same as the carbon transmitter universally adopted for telephone use. In such a transmitter a small amount of power in the form of sound releases to an associated receiver a much larger amount of power from a local source of electrical energy. If the transmitter is sensitive and the receiver connected to it is efficient, and if both are well designed, the sound delivered to the ear will not only be a fairly faithful copy of that reaching the transmitter, but will also be materially amplified in intensity. The simplest form of audiphone, therefore, requires only two transmission instruments; a sensitive transmitter and an efficient receiver, of good design.

The amplification that can be obtained with this simple form of audiphone, however, is limited, and is often inadequate to compensate for a serious loss of hearing. When the earliest electrical hearing aids were designed in Bell Telephone Laboratories, it was believed that the additional amplification needed could best be secured by vacuum tube amplifiers. Several such sets were manufactured on a commercial basis, and their use over a period of years provided valuable practical information with which to determine the requirements for a thoroughly satisfactory hearing aid. Assisted by this information, and by improvements which had meanwhile been effected in allied apparatus, further development yielded the present commercial forms of Western Electric audiphones.

It proved feasible to utilize again the amplifying ability of a carbon transmitter in providing a mechanical amplifier which increases the output about a hundred times, an amount equivalent to one stage of vacuum tube amplification, without adding materially to the size or weight of the audiphone. The new Western Electric audiphone, therefore, consists essentially of the three elements shown in Figure 1: a new transmitter and receiver, and an amplifier of the sort just described. The transmitter, at the left, is less than 2½ inches in diameter, and the receiver at the right, which weighs less than ¾ ounce, is only ⅞ inch in diameter. These small dimensions are only the most conspicuous of the many advantages provided by the special design of the transmitter and receiver.

The audiphone, furthermore, gives the sufferer from impaired hearing almost all the auditory experience he has. He depends entirely upon its fidelity, and it is important that he receive a high grade of service. The transmitter is accordingly specially designed to minimize erratic transmission, carbon noise and carbon aging. The receiver contains an electromagnet, supplied with magnetizing current by the same battery that supplies current to the transmitter and the amplifier. After the receiver has been assembled, the pole piece of this magnet is adjusted to such a position, relative to the receiver diaphragm, that the receiver as a whole will have maximum efficiency and is then sealed in place.

The amplifier is the most unique element in the audiphone. As has already been pointed out, it consists of two parts, similar respectively to the receiver and the transmitter. The electrical output from the audiphone transmitter passes through the winding of the receiver part. This varies the magnetic field in the air gap of the magnetic circuit, whose metallic portions are of permalloy, and so causes a permalloy diaphragm to move correspondingly. The permalloy diaphragm drives

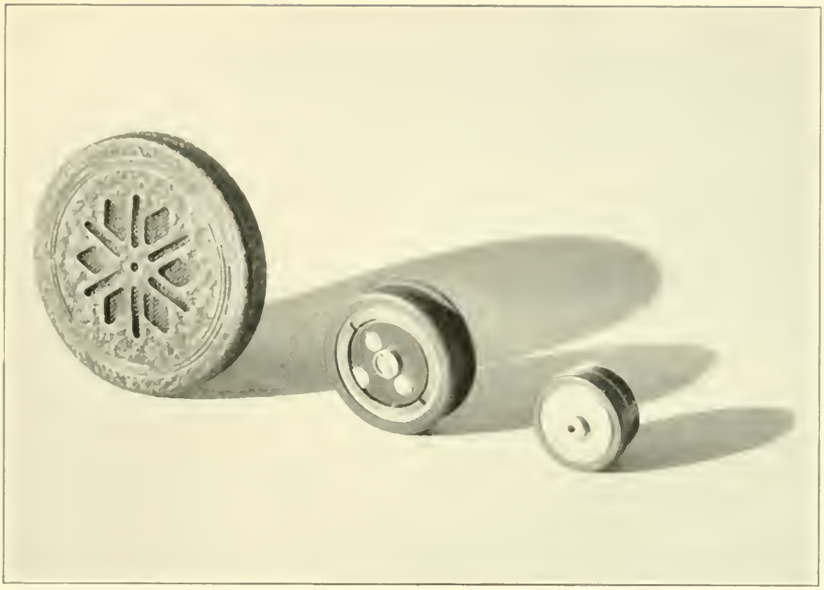

Figure 1. Transmitter (left), Amplifier, and Receiver (right) for the New Audiphone.

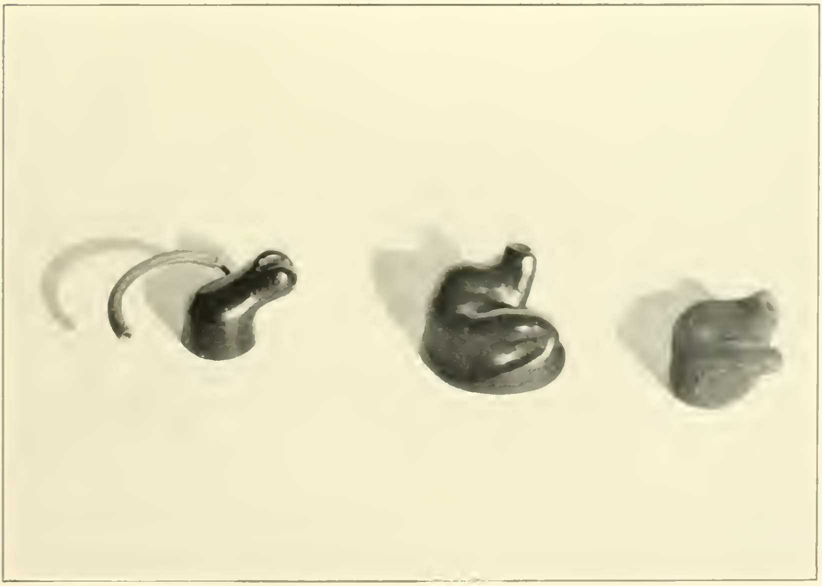

Figure 2. The Older Universal Type of Earpiece, on the left, May Be Adjusted to Conform to the Ear, While the Individual Type, in the Center, Is Specially Moulded for Each User. Universal Earpieces of Soft Rubber Are also Available in Four Sizes, of Which One Is Shown at the Right.

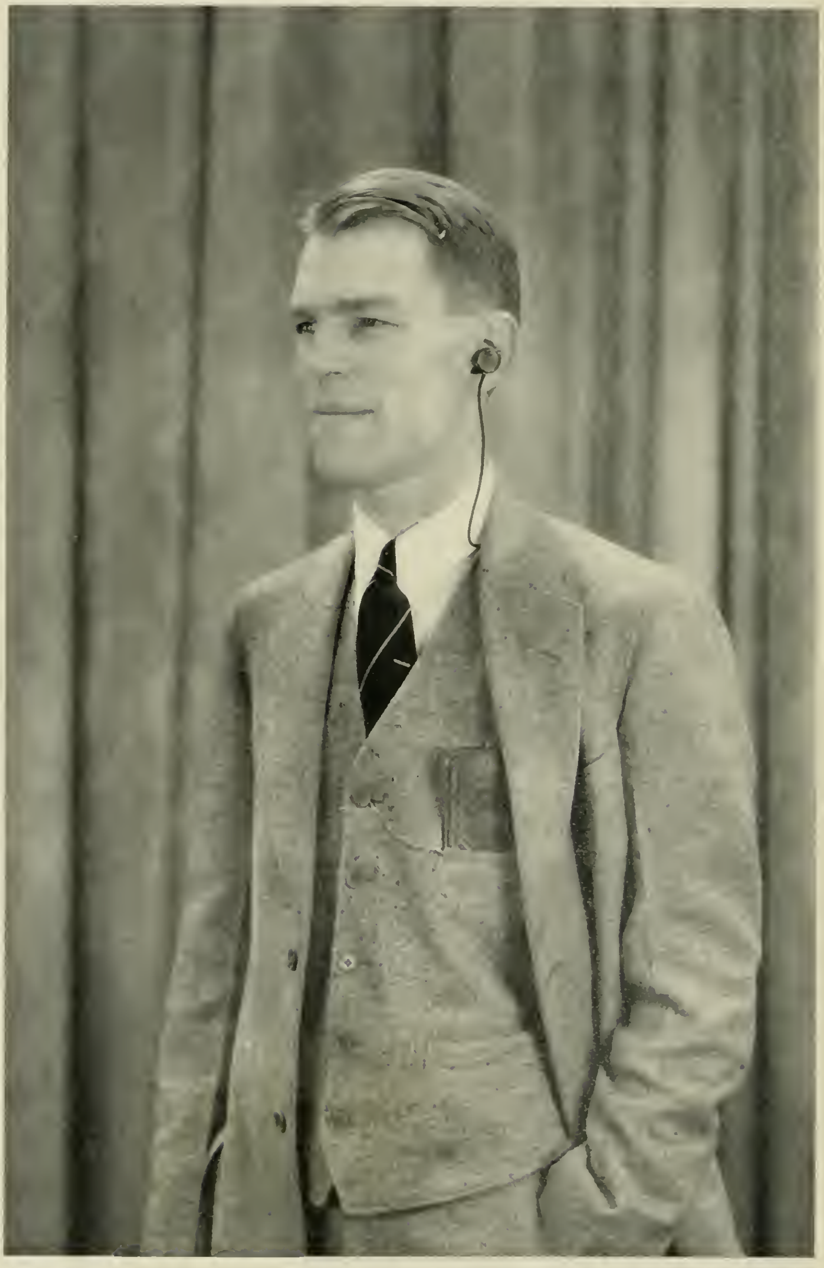

Figure 3. In the 38A Audiphone, the Transmitter, Amplifier and Rheostat Are Mounted in a Pocket-size Case.

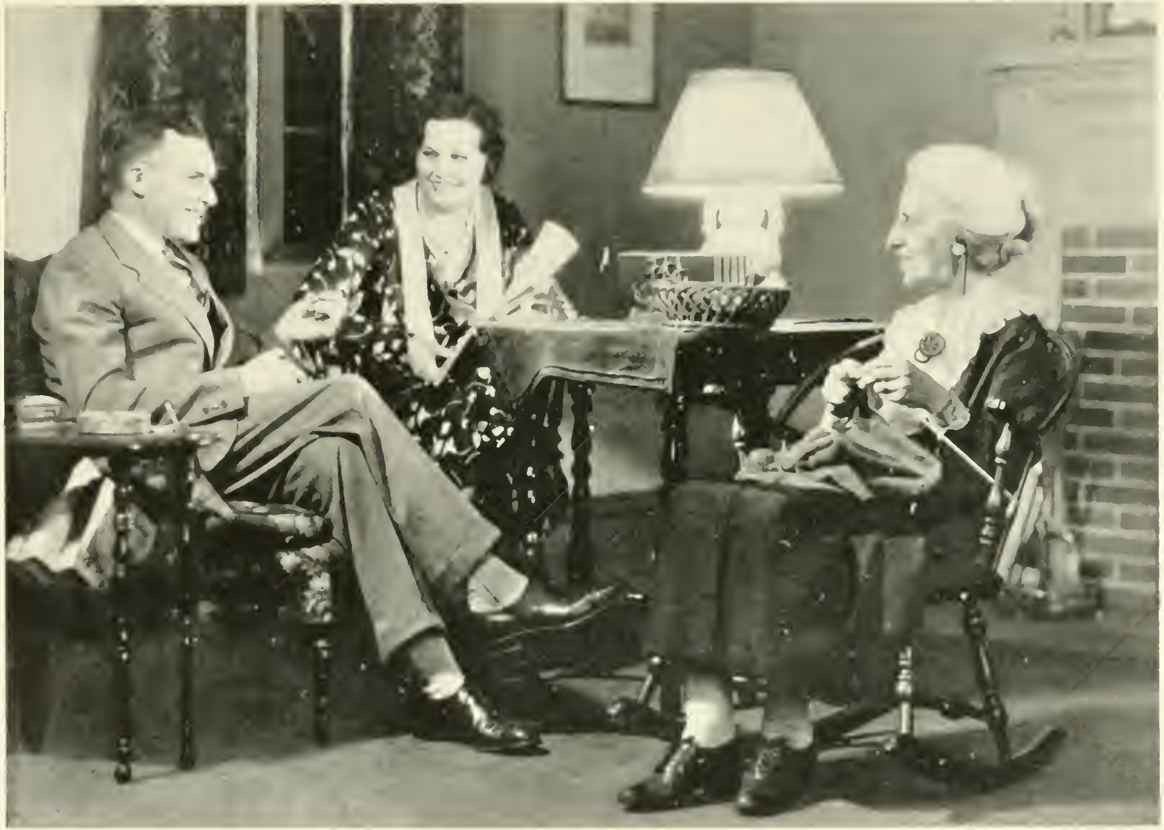

Figure 4. The 36A Audiphone Employs No Amplifier but Has a Wide Field of Use with Those Whose Hearing Is Only Moderately Impaired.

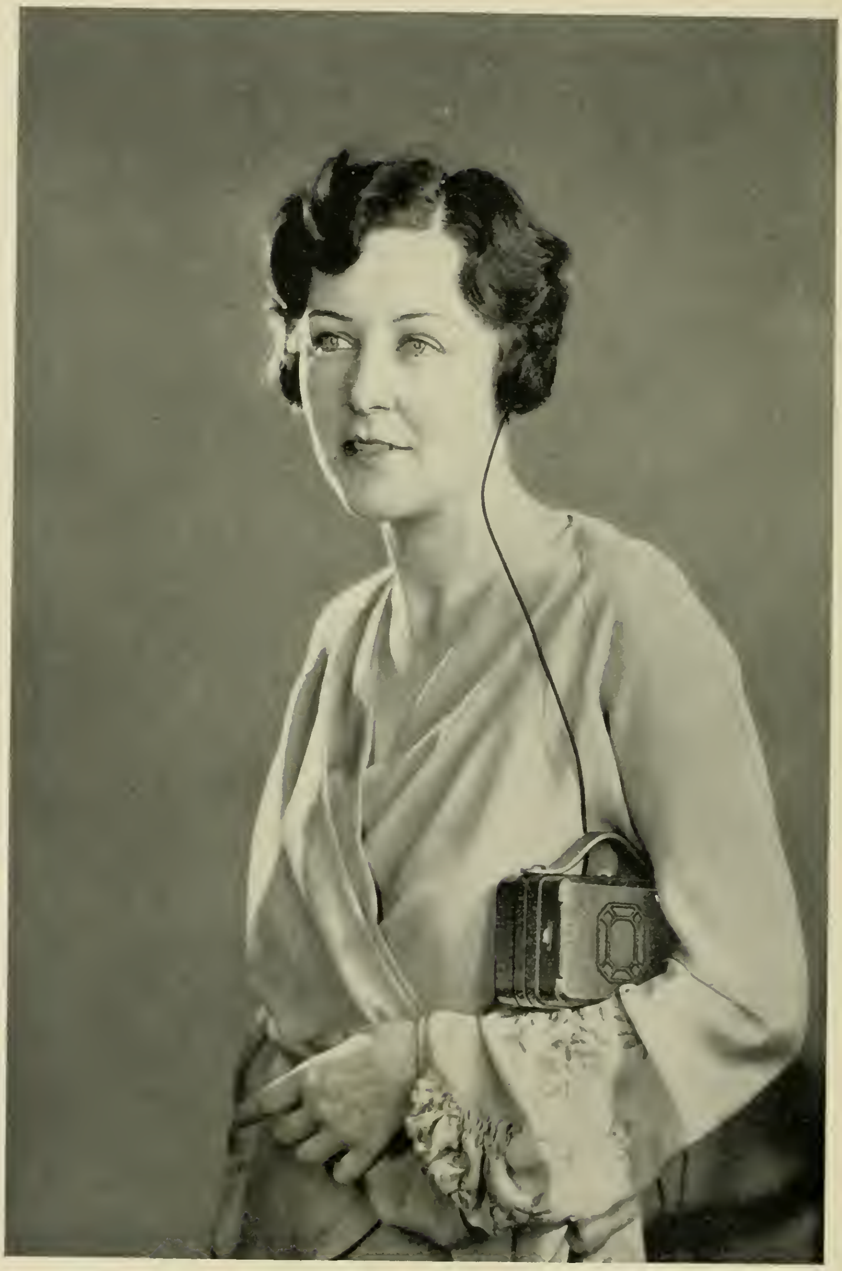

Figure 5. Still Another Alternative Arrangement Is Provided by the 12A Carrying Case Which Assembles the Complete 38A Audiphone and Battery in a Single Unit.

a copper diaphragm of similar dimensions through an air coupling formed by the narrow air space between the two. The copper diaphragm acts on the granular carbon as does the diaphragm of a transmitter, and produces the desired amplification. The amount of amplification can be adjusted by a rheostat in the circuit.

The final step in transmission, from receiver to ear, is accomplished by the earpiece, which is made so that it can be rigidly attached to the receiver and closely fitted into the ear. Of the three types available, shown in Figure 2, one is individually moulded to fit the ear of a single user, and the others are universal types. The older universal earpiece, of hard rubber, is made in four sizes and can be adjusted to fit the important dimensions of any user's ear. The new universal earpiece is made of soft rubber and also in four sizes, one or another of which will fairly satisfactorily fit almost any ear. The individual type is preferable to either of the others, because it distributes the pressure uniformly on the ear, whereas the universal types must concentrate a certain amount of pressure to prevent acoustic leakage around the earpiece.

The commercial sets embodying this apparatus are made with two different groupings of the elements. With one, in which the transmitter is separate and the rheostat and amplifier are combined, the transmitter may be worn inconspicuously and the combined rheostat and amplifier may be placed in the pocket. In the other, maximum compactness has been achieved by combining transmitter, amplifier and rheostat in a single unit (Figure 3). In both these sets the battery is kept separate so that either a battery box with standard flashlight cells or a special audiphone battery can be used. For use with the more compact set, there is a carrying case which will accomodate the battery also.

A third set is made without an amplifier for those whose hearing is not greatly impaired but who do require some aid (Figure 4). Ordinarily even these people, however, find it valuable to have the greater flexibility of volume range provided by the greater amplification of the other sets.

The transmitter for these sets has an attractive geometric design on the face and is finished in a blue-gray crinkle lacquer which blends well with almost any color and fabric. A clip on the back makes the transmitter as easy to attach to the clothing as a fountain pen. Of the set without amplifier there remain to be concealed only the rheostat and the battery, both of which will readily fit in a pocket. For the sets with amplifiers, the containing cases are comparable to cigarette cases in size, and are finished like the transmitter in blue-gray crinkle lacquer. The carrying case for the compact audiphone contains the entire equipment (Figure 5); the instrument can either be used in the case or worn on the person.

Even the minor elements of these sets have been designed with great care. Thus the twisted cord used in earlier models has been replaced by very small "concentric" cord, which is easy to handle, consisting of an insulated flexible conductor, around which another conductor is woven in the form of a cylinder. So effectively have the size and weight of all components been reduced that the compact set, including three flash-light cells which weigh about a pound, weighs less than a pound and three quarters, and can be so disposed in use that practically nothing is noticeable but the small receiver and part of its connecting cord.

Interesting considerations arise in the attempt to rate the value of the new audiphone. Because of the large number of factors contributing to one's ability to understand speech, the value of a hearing aid is difficult to determine. Experience has shown that the most satisfactory way is to make a test to determine the percentage of typical sentences which can be understood. In applying the test, the user of the audiphone is seated about three feet from a speaker who reads in a conversational voice a number of sentences such as "Fire insurance is desirable; Washington was called the father of his country;

it is dangerous to throw away a lighted match." From a record of the number of statements understood with and without the audiphone, the usefulness of the audiphone can be measured.

The case of Mr. A illustrates that many precautions must be taken in interpreting these results. When ten sentences are addressed to Mr. A without the audiphone in use, he understands only two completely, although he hears snatches of others. He is then requested not to watch the speaker, and of the next ten sentences he fails to understand any, although again he hears parts of several. Apparently Mr. A has some lip-reading ability, although he may be unaware of it. Mr. A again watches the speaker, the test is continued with the audiphone, and he quickly and correctly repeats every sentence.

Mr. A hears so well with the new audiphone partly, of course, because of its careful design, but his history helps the audiphone to give him so much satisfaction. By using a hearing aid for years, he has kept his ears in an environment of speech—always interpreting through hearing regardless of distortion. He does not have to learn again to interpret through his ears. Someone else, who has an identical hearing loss but who has withdrawn from contacts where he must depend on hearing, may not be able to obtain so much aid from the audiphone at first. As he uses it, however, he will become increasingly proficient in interpreting what he hears, and the audiphone will give him more and more satisfaction.

Mr. A's test is not hypothetical, it is one of many that have been made with the new audiphone. Some of those tested have had only moderate hearing losses; others have had very little useful hearing range. The results obtained with the audiphone have varied correspondingly, but very few people have been found whose hearing loss was so great that they were not able to carry on conversation with the help of the new audiphone.

The tragedy of Beethoven's deafness is but a private tragedy come to public notice. Thousands of similar tragedies have been no less acute because less renowned, for each man's enterprises are as important to him as Beethoven's were to the world. Past years have each claimed a quota to be debarred from travelling one of the main avenues to life's experiences. It will gratify members of the Bell System to know that its studies of the needs of these sufferers have enabled it to swing back the ancient barrier.

A. N. Holden

The Growth of America's Communication Needs

IT is scarcely a coincidence that both the telegraph and the telephone were invented in America. It is certainly no accident that the art of electrical communication has had its greatest development in the United States. With a pioneer people thinly spread over a continent, the need for communication was imperative. From this need came the urge to invent, the urge to develop. The changing frontiers of American life and two inventions that themselves were on the frontiers of science were, to a large degree, cause and effect.

Widely diversified in soil and climate, in mineral wealth and in industrial or commercial opportunities, the original colonies early established trade relations for the interchange of necessaries, thus setting up the economic basis for communication facilities. Families moved from one section to another, leaving relatives and friends behind, a separation which formed the social basis that made some form of communication desirable. Under these economic and social compulsions for communication, pathways were cut through the forests, sailing vessels skirted the coast and post riders took adventurous journeys across mountains and through streams. Life and death, as well as business success or failure, depended upon the delivery of messages, as they do today in times of emergency.

To the economic and social needs of the colonies for communication there were added political exigencies. When the colonists found themselves faced with the War of Independence, one of their first acts was the establishment of a system of postal routes, independent of those maintained by the Crown. In order that the Revolution might be carried on successfully, co-operation between the widely separated colonies was essential, and this necessitated means of communication which were at once prompt, dependable and safeguarded against the operations of British spies or hostile Indians.

That the colonies were not at first fully awake to the importance of communication facilities as factors in their fight for liberty is evident from the fact that it required a considerable amount of propaganda to bring about the establishment of this "constitutional" postal system, in opposition to that carried on by the British government. It is on record that the establishment of what is now the United States mail service may be traced largely to the efforts of one William Goddard, a printer, who went from colony to colony urging the step. In 1775 the Continental Congress appointed Benjamin Franklin as Postmaster-General, an office he had held with distinction under a former appointment by the Crown. When Franklin sailed for France to negotiate for a treaty between that country and the newly established republic, he turned the office over to his son-in-law, Richard Bache, who served until 1782. It is interesting to note that when Franklin resigned as head of the postal system, there were only seventy-five post offices in the entire country and that the total length of American postal routes was only 1875 miles.

Washington, Communication Pioneer

The political importance of communication facilities continued for many years after the Revolution to be an increasingly vital factor in America's development as a nation. Indeed, it fell to Washington to take what was probably the first real step toward providing adequate means of contact with the more remote American settlements. Few public men of his time understood as clearly as he did how important the western territories were to the new nation or how necessary it was to provide closer ties with the Americans who had gone there to make their homes.

Washington's interest in this matter was of long standing, probably dating from his historic journey to the French forts along the Ohio in the service of Governor Dinwiddie of Virginia in 1754. In 1770 and the two following years he made additional trips over the mountains westward as a result of which he began an active campaign for the improvement of the navigation of the James and Potomac Rivers, introducing a bill for that purpose before the Virginia House of Burgesses in 1774. The bill failed of passage, and the outbreak of the Revolution turned his thoughts, like those of all of his countrymen, toward war.

When Washington returned to Mt. Vernon at the close of hostilities, his attention again was focused upon the project which had been dear to him before the conflict. On September 1, 1784, he left for a trans-mountain tour in order to obtain further data regarding conditions and requirements. He traveled more than 600 miles, on horseback and on foot, and returned with a report, filed with Governor Harrison, of Virginia, that included the first general outline of a system of public improvements in the history of the country.

Citing conclusive facts to prove the importance of the western territory, he hinted that, without adequate means of communication, the settlers beyond the Alleghenies were likely to be drawn in their economic interests, if not in their political allegiance, either to the British on the north or to the Spaniards on the south.

"The great object," he wrote to Edmund Randolph in 1785, "for which I wish to see the navigation of the Rivers James and Patomack extended is to connect the Western Territory with the Atlantic States; all others with me are secondary."

It is interesting, and of considerable importance as bearing on the later development of communication and transportation in America, to note that the project in which Washington was chiefly interested—the improvement of the navigation of the Potomac—was undertaken, not as a public but as a private enterprise. Virginia and Maryland having enacted laws authorizing the organization of a company for the improvement of the Potomac River, subscription books were placed in the various towns of these two states, and when these were opened, on May 17, 1785, it was found that a total of 403 shares had been subscribed, for a total of £40,300.

The policy of financing improvements in transportation and communication as privately-owned enterprises, rather than as public projects, thus early inaugurated, has been very generally adhered to throughout American history. With a few exceptions, such as the National or Cumberland Road, the facilities which have been created to meet America's growing communication requirements have been inspired by private initiative and carried to completion by private capital. It was thus that most of the nation's turnpikes and canals were built and all of its railroads constructed. So, too, years later, when Morse invented the telegraph and Bell gave the world the first telephone, it was private enterprise and the investment of private funds that developed these inventions into the far-reaching systems of communication they now are.

Among those who blazed the trail for this extensive development of communication facilities, one of the foremost was Washington. Because of his interest in internal improvements, he has been called America's first expansionist. Certainly he was among the first of Americans to see that all true expansion must be based upon the provision of adequate facilities for transportation and communication. Simple as this seems, it was to become the issue of many a heated political conflict before the nation had reached full stature.

An Era of Territorial Expansion

When the question of the Louisiana Purchase was before the United States Senate, Senator James White of Delaware, while approving the acquisition of New Orleans and such other ports on the Mississippi as were necessary to open the river for navigation, declared that "as to Louisiana, this new, immense, unbounded world, if it were ever to be incorporated into this

Union, which I have no idea could be done except by altering the Constitution, I believe it would be the greatest of curses that could at present befall us."

He further contended: "Louisiana must and will be settled, if we hold it, and with the very population that would otherwise occupy part of our present territory. Thus our citizens will be removed far from the capital of the Union, where they will scarcely ever feel the rays of the general government; their affections will become alienated; they will gradually begin to view us as strangers; they will form other commercial connections and their interests will become distinct."

Even so clear-eyed an explorer as Lieut. Zebulon M. Pike, who headed two expeditions into the prairies west of the Mississippi and far into the hills and mountains beyond them, could see but a single advantage in these vast stretches of "desert" —that of preventing the further spread of population over the west.

"From these immense prairies," he wrote, "may be derived one great advantage to the United States, namely the restriction of our population to some certain limits, and thereby the continuation of the union. Our citizens being so prone to rambling and extending themselves to the frontier will, through necessity, be constrained to limit their extent to the west to the borders of the Missouri and the Mississippi, while they leave the prairies, incapable of cultivation, to the wandering and uncivilized aborigines of the country."

But the propensity toward "rambling and extending themselves to the frontier" urged Americans westward in waves of population, over sands, rivers, prairies and mountains, until they had reached the Pacific. Every movement of settlers created its own political problems and these, in turn, created problems of communication and transportation.

As late as the days of the Oregon controversy, when railway transportation in the east was well under way, statesmen seriously debated the question whether it was worth while to lay claim to the territory, because of its remoteness and the apparent impossibility of maintaining adequate communications between it and the eastern sections of the Union. One legislator declared that it would take a representative from that part of the country a year to make the round-trip journey to Washington, while Webster himself heatedly affirmed that he "would not vote one cent from the public treasury to bring the Pacific coast one inch nearer to Boston than now."

The conservatism of executives and legislators did not, however, stay the onrush of settlers to the West. Marcus Whitman, missionary and practical patriot, had taken a wagon over the Rockies even while pessimists were solemnly asserting it could not be done. Gold was discovered in California with consequences known to everyone. Homesteads began to dot regions hitherto known only to trappers. Towns sprang up where there had been only virgin forest or unobstructed plain. The Empire of the West was in the making.

But this advance of the borders of settlement was made possible only by the establishment of lines of communication with the eastern and southern bases from which these armies of settlers had moved. Covered-wagon trail, Pony Express route, railway, telegraph and telephone in turn played vitally important parts in the winning of the West. It is hardly too much to say that, from the standpoint of political unity, this vast expansion would have been impossible in the first place without communication ties binding section to section. If it had been possible, it could have been accomplished only with the gravest danger to the integrity of the Union.

A NATION OF MANY TONGUES

Meanwhile the need of communication had become important for another reason. Immigrants from Europe were pouring into the United States in increasing numbers. They were people of many tongues and races. Their assimilation soon became a problem. No physical frontiers now separated them, race from race, as often had been the case in their homelands. Here they were neighbors. Each with his own racial characteristics, traditions and antipathies, they were forced to find common ground upon which to unite as Americans. Without communication, they might have withdrawn, each group to its own section of the country, to perpetuate in a new land the disunities of the old.

The admission to the Union of states which had originally been settled by non-British also presented a social and political problem which gave added importance to the development of communication facilities. Many of the pioneers of Louisiana were French, many of those in Florida and in sections included in the territory obtained from Mexico were of Spanish origin. If anything like a national consciousness was to be brought out of this addition of territories and states with dissimilar human ingredients, there had to be dependable and reasonably prompt means of communication between one section of the country and the others. Without such facilities for exchanging ideas, the expansion of the country would have been the making of a political patchwork, each part with its individual racial and political background and its own language and traditions.

To many students of American history it seems providential that, at the very moment when this remarkable spread and heterogeneity of population was beginning to assume full momentum, Morse should have begun experimenting with an instrument which was later to become the electric telegraph. It is a striking coincidence that his first message should have been sent over the first telegraph wire at the very moment when there arose in the United States the greatest need for communication facilities.

The telegraph lines soon began to creep westward. In less than two decades they had reached the Pacific. As the coming of steel and steam and the development of the railway postal service had been followed by an accelerated movement of population toward the setting sun, so the advent of the telegraph was a signal for a further quickening of pace in the march of civilization across the continent.

The provision of the new communication facilities made possible by the development of the railway postal service and the telegraph, moreover, had another effect than that of merely increasing the numbers of those who turned their faces westward. Puffing locomotive and clicking telegraph were potent factors in attracting to this land of wider horizons a new type of men and women.

When the only ties with the East were trappers' trails or the wheel-marks of infrequent prairie schooners, a large percentage of those who set out for the West was made up of men—and women, too—in whom a spirit of romantic adventure was an almost universal characteristic. With the advent of the railway and telegraph, even the less hardy souls, who had hesitated to isolate themselves in these remote western regions, began to answer the call of new and alluring opportunities. Hamlets grew into villages, which in turn became bustling " boom towns " and, eventually, cities. In the wake of the adventurers came the homemakers, the builders of industries, the creators of states. Railroad and telegraph communication with the East helped to assure to these western regions an influx of newcomers who, if they lacked some of the spectacular daring of those who had blazed the first western trails, had qualities which contributed greatly to the making of America.

Changing Economic Conditions

While these western migrations were taking place, there were occurring changes in national economic conditions that were destined to play important parts in making necessary the network of telegraph and telephone wires that now crisscross the continent.

Despite the exodus of thousands of pioneers to newly opened territories in the West, population had begun to congest along the Atlantic seaboard, particularly at points where harbor facilities were such as to encourage export and import trade. For some decades, America's large cities were confined to areas on or near its eastern coastline. Throughout this region generally, and in New England in particular, climate and soil were not such that these large cities could be sustained by the lands immediately adjacent to them. Foodstuffs had to be brought to them from a distance which increased as their population mounted. Transportation had to be provided in order that these necessaries might be carried from the point of production to the point of consumption. Wagon roads, canals and, finally, railroads, were built, each in response to this necessity. But the need for these facilities was not merely one for transportation of commodities. Hardly less urgent was the demand for carrying messages between these widely separated points.

Foodstuffs had to be bought and sold before they could be shipped and consumed. It was wasteful of time and energy for the buyer to go to the source of supply for his goods, or for the seller literally to carry his goods to market. Messages of one kind or another supplanted these face-to-face transactions. In conducting business negotiations, men no longer went—they sent. Communication began to be an important factor in America's internal commerce.

So with other necessaries than food. Until the development of steam and electricity, manufacturing plants were located along streams from which water-power could be obtained conveniently and cheaply, often at considerable distance alike from the source of raw materials and the market for the finished product. Out of this fact grew new requirements for better, more prompt, more dependable communication facilities. The producer of raw materials, the manufacturer, the retail merchant and the consumer had to be linked by ties which would enable each to keep in touch with the man with whom he immediately dealt—and that without stopping work. More than ever before, words became the tokens with which trade was carried on.

As larger cities were built in newly opened territories, each became the center of a new market, demanding lines of communication running back to the source from which its necessities came. If these cities were to live, they had to maintain these ties. To be decently fed and clothed and housed, people had to exchange messages with people of other regions.

Rising Standards; Wider Markets

For a multitude of economic reasons, America became a land of rising standards of living. Each generation lived more comfortably than that which had preceded it. The luxuries of one decade came to be looked upon as the necessities of the next. To the four corners of a continent rich in widely diversified resources Americans sent for those things which they ate, with which they clothed themselves, or with which they built their homes. Trade was no longer confined to transactions in what had once been looked upon as necessaries. As the diversity of products increased, so also did the volume. The era of quantity production had its origin in the demands of a growing nation and in living standards that were mounting higher and higher. Every addition to commercial activity augmented the demand for more widespread communication facilities.

The development of quantity production by manufacturers, mine operators, farmers and lumbermen brought about a production policy which in America has reached a point equalled nowhere else in the world. This policy of quantity production soon made it necessary to reach out continually for wider markets. Modern methods of manufacture also have called for the establishment of branch factories in many widely separated parts of the country. Sales organizations, too, have covered the country from coast to coast. The profession of advertising has contributed an important part toward the creation of new wants and new markets. Every one of these developments would be impossible without adequate systems of communication.

The past half century in America, then, has been an era of ever-increasing demands. The descendants and successors of the restless, adventurous pioneers who first settled the country have been impatient of any kind of limitations. Because Americans have wanted so many things, and have insisted on getting them, America leads the world in the development of electrical communication facilities. One's wants cannot be satisfied unless they are made known. When they are to be satisfied from a distance quickly, they must be made known quickly. Prompt communication is as important a factor in meeting these wants as is transportation.

A Prophetic Telephone Message

At about the same time as the beginning of this period of America's enlarged social and economic demands, Alexander Graham Bell spoke over the first telephone line the first sentence of speech transmitted electrically. That sentence was: "Mr. Watson, come here, I want you." It was as if this young Scotch-American had voiced a prophecy to be realized even during his own lifetime, when the telephone, thus brought into being, would become an instrumentality of expressing the wants of America. It was as if he had foreseen the day when one American, anywhere within the borders of the country, could call out to another American, anywhere: "I want you. I want the things you have—the goods you have to sell; your market for my products; your skill as a professional man; your assistance as a protector of life and property; your word of counsel or sympathy as a friend."

Americans have wanted these things; have demanded the facilities which would make it possible to express these wants, and to express them quickly, over vast distances. Out of this demand have grown America's communication systems. Not otherwise could these networks of wire be created, nor the demands met.

R. T. BARRETT

Certain Significant Features of the Census of Distribution

THE Census of Distribution[1] taken in 1930 by the Federal Government constituted a new venture in census-taking, undertaken in response to an expressed need for definite information on this phase of American economic life. Statistics of the productive industries—agriculture, manufacturing, etc. —had been regularly assembled in each decennial census (or more frequently), but only in the last decade had the problems involved in the moving of goods from producer to ultimate consumer become sufficiently pressing to call for the collection of a body of data relating to the whole distributive process.

The census furnishes an immense volume of facts on both wholesale and retail trade: dollar sales, number of establishments, types of business organization, business expenses, etc., for a detailed classification of kinds of business, by states and for the largest cities; wholesale data are reported in less detail for counties and for all places of 5,000 population and over; figures on retail sales and number of stores are also reported for all places of more than 1,000 inhabitants and for counties. With all this information available for the first time, the census material will be found highly useful both to those engaged in the business of distribution and to those who regard the distributive field as a market for their services or who have services to sell directly to the ultimate consumer. Any light it can shed on the economic life of the country, and whatever value or limitations the data may have as a measure of potential markets, are of inherent interest to the telephone industry.

It is, of course, inevitable that the data should have their limitations. Because it was a new type of inquiry there were difficulties of classification and lack of proper records from which to furnish information; because the census was taken on the basis of establishments, certain types of businesses, particularly some of those dealing in agricultural products, were not included. Moreover, the arbitrary decisions which had to be made in classifying some establishments as engaging either in a wholesale or in a retail trade or in designating the "kind of business" under which a given firm should be placed led to some inaccuracies, with the result that all the figures must be regarded as indicating the general situation rather than as being exactly descriptive.

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[1] The early reports of this census were analyzed in an article by R. L. Tomblen in the BELL TELEPHONE QUARTERLY for October, 1931, " Preliminary Returns of the Distribution Census."

One thing which is at once apparent from the data is that the line of demarcation between wholesaling and retailing is not clearcut. The fundamental difference is, of course, that wholesalers are engaged primarily in the collection of goods from manufacturers or other producers and the distribution of them to retail merchants for resale, while the retailer is engaged only in the final process of distribution to the ultimate consumer. Most wholesale houses, however, have occasion to make some sales at retail, while at times retailers sell to other retailers on a wholesale basis. Furthermore, manufacturers enter into the distribution field by selling some goods directly to retailers and some to consumers. These are elements which complicate the picture of distribution and indicate plainly that a considerable share of the goods ultimately consumed does not pass along the conventional path from producer to wholesaler to retailer to consumer.

Sales Made in Other than the Conventional Manner

Channel	Amount	Per Cent of Total Business of Seller
Manufacturing Plants to Retail Organizations	$13,009,588,000	20.5
Manufacturing Plants to Industrial and Other Large Consumers	19,849,875,000	31.3
Manufacturing Plants to Household Consumers	1,553,367,000	2.5
Wholesale Organizations to Industrial Consumers	15,003,922,000	21.7
Wholesale Organizations to Ultimate Consumers (at Retail)	689,817,000	1.0
Sales of Retailers to Other Retailers	706,776,000	1.4
Sales of Wholesalers to Other Wholesalers	Unknown but small	

The net sales reported for 1929 by all wholesale establishments included in the Census of Distribution amount to $69,291,548,000, while the net sales by retail establishments total $49,115,653,000. If to these figures are added the $34,400,000,000 of sales made by manufacturers without a wholesaling intermediary, the $4,500,000,000 of the products of extractive industries not flowing through wholesale channels and the unknown but sizeable sales of dealers operating without fixed establishments, the total transactions in the field of distribution reach approximately $160 billion per year.[2] And of these $160 billion, about 35 per cent are sales made in ways other than those included in the popular conception of the step-by-step distributive process.

The major part of the sales directly to industrial consumers, shown in the above table, of course represents raw materials, goods partially fabricated, or equipment to be used in the further production of goods. The largest net sales, whether made by manufacturers or wholesalers, are in iron and steel and their products, machinery and other equipment, and textiles and raw cotton. On the other hand, the sales of manufacturers to retailers are mainly in various types of food products and finished textiles, and over 50 per cent of those to household consumers are in food products. One-third of the retail sales by wholesalers are in automotive products, and the same proportion holds for the sales by retailers to other retailers. This last item is largely sales to used-car dealers of automobiles accepted as part payment for new cars.

Distribution activities engaged over 7,000,000 people in full-time occupation in 1929 and nearly another 700,000 in part-time work. Together these groups made up almost 16 per cent of all those gainfully occupied in the United States.

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[2] It should be borne in mind that all figures in the census relate to conditions in 1929.

Wholesale Trade

Wholesale trade is highly concentrated. Five-sixths of the total sales in 1929 were made in 127 counties in the United States, while one-sixth was distributed among the remaining 2,947 counties. This fact acquires added significance when it is realized that these same 127 counties accounted for only slightly more than half the retail sales and that only 41 per cent of the country's population lives in them. These counties are essentially urban in character and include most of the cities of the country which have 100,000 inhabitants or more. Over 75 per cent of the total wholesale business was transacted in such cities, and 57 per cent of the total in those located in the area east of the Mississippi and north of the Ohio and Potomac rivers.

The trade in certain commodities is even more heavily concentrated. The sales of industrial machinery, equipment and supplies, for example, are made chiefly in the industrial northeast and in such isolated industrial areas as exist in Texas and California, as are also sales in metal products to be further fabricated—iron and steel, copper ingots, etc. On the other hand, the sales of food products and groceries are much more closely related to the general distribution of the population.

The census classifies as wholesalers, in addition to wholesale merchants and manufacturers' sales branches, agents and brokers who frequently do not actually take title to the goods they buy and sell, co-operative sales agencies, chain store warehouses distributing only to their own retail stores, wholesalers who also do some manufacturing, as well as the assemblers and country buyers of agricultural products, and some other less important groups. The type of wholesaler varies, to a large extent, with the type of commodity handled. Nevertheless, the "old-line" wholesale merchant holds a dominant position, having transacted 36 per cent of all the wholesale business in 1929 and being represented in almost all lines of trade. The principal types of wholesalers and the lines in which they do their largest volume of business are as follows:

	Per Cent of Total Wholesale Trade	Principal Lines of Business
Wholesale Merchants	36	Generally Represented
Manufacturers' Sales Branches..	21	Meat Products, Coal, Machinery
Agents and Brokers............	21	Farm Products, Food Products
Country Buyers and Assemblers	7	Cotton, Grain, Tobacco

The pattern of the wholesaling process has become more and more complex as new methods of distribution have been introduced to meet the changing conditions of modern business life. Chain store warehouses, for example, have assumed importance as chains have increased their proportion of the retail business, especially in the groceries and food specialties, dry goods, and drug lines. Others known as "cash and carry" wholesalers, wagon distributors, and mail-order wholesalers are now doing a business which is a small part of the total trade, but which is an indication of the efforts being made towards reducing the cost of distribution by curtailing some of the usual services.

Expenses in Wholesale Trade

The expense of carrying on a wholesale business is an important element in the final cost of commodities to consumers. The relative cost as a proportion of the net sales (cost including total salaries and wages, salesmen's expenses, rent paid, interest on borrowed money and incidentals) varies with the volume of business, the type of commodity handled, etc. For the country as a whole, the relative costs among wholesale merchants as a class decrease consistently as the volume of net sales increases; this also holds true for dealers in all the 24 general kinds of business listed by the census except for minor variations, as is shown in the accompanying table. The ratio of expenses to sales is on the average 64 per cent lower among concerns with average sales of $1,000,000 or more than among those with sales of $25,000 or less. The distributors of metals

Kind of Business	Volume of Net Sales									
	Total	Under $25,000	$25,000 to $49,999	$50,000 to $99,999	$100,000 to $199,999	$200,000 to $299,999	$300,000 to $399,999	$400,000 to $499,999	$500,000 to $999,999	$1,000,000 and Over
Total	12.2	26.9	21.8	19.4	16.9	15.3	14.3	13.4	13.0	9.7
Amusement and Sporting Goods	23.7	46.9	32.7	32.2	25.4	25.5	23.5	22.3	24.2	17.7
Automotive	15.0	32.4	27.0	26.3	25.1	22.4	22.5	20.6	18.4	10.8
Chemicals and Drugs	16.3	37.6	30.2	24.8	22.2	22.5	20.2	15.9	16.5	14.0
Dry Goods and Apparel	13.6	21.2	17.4	15.9	14.4	13.9	14.1	13.5	13.0	13.2
Electrical	16.9	34.2	27.7	22.8	22.4	20.7	17.6	17.7	16.6	14.8
Farm Products	5.5	28.2	23.3	15.7	11.9	9.5	10.5	8.2	6.9	4.4
Farm Supplies (except machinery)	8.9	25.4	13.9	15.3	13.2	11.6	12.6	12.4	9.6	7.2
Food Products	10.5	20.7	16.5	14.6	13.1	12.0	11.2	10.1	10.6	8.8
Forest Products (except lumber)	11.3	31.1	23.7	20.1	18.8	14.5	12.6	12.7	9.4	5.5
Furniture and House Furnishings	19.0	34.8	25.7	28.9	22.1	21.6	20.0	22.2	20.7	14.3
General Merchandise	8.8	21.9	17.8	15.2	16.6	12.1	13.7	10.0	14.1	8.2
Groceries and Food Specialties	9.0	22.4	18.3	14.3	10.8	9.5	9.4	9.0	9.3	8.1
Hardware	18.8	30.2	26.9	22.0	20.8	18.8	20.7	19.6	19.0	18.3
Iron and Steel Scrap, Other Waste	12.7	26.8	20.4	18.3	16.5	15.5	14.7	14.7	13.2	7.9
Jewelry and Optical Goods	17.9	27.3	22.2	19.2	17.0	17.7	15.9	16.6	17.9	18.2
Leather and Leather Goods (not gloves and shoes)	12.2	16.6	14.9	15.1	15.8	16.4	12.7	11.9	13.1	8.6
Lumber and Building Materials (not metal)	17.2	39.1	33.1	28.0	22.7	20.4	19.5	18.8	16.9	12.9
Machinery, Equipment and Supplies (except electrical)	19.4	34.2	27.9	25.5	23.0	21.5	20.4	18.7	18.5	13.9
Metals and Minerals	7.5	32.8	23.7	19.4	17.1	15.2	11.5	14.7	11.0	5.5
Paper and Paper Products	16.6	22.8	21.2	22.1	20.6	20.4	17.8	17.8	17.4	13.7
Petroleum and Petroleum Products	14.9	21.7	16.8	16.3	17.8	18.1	16.2	18.7	15.0	13.2
Plumbing and Heating Equipment and Supplies	20.0	37.5	27.1	22.5	19.4	20.7	18.7	17.7	20.7	19.6
Tobacco and Tobacco Products	7.5	12.3	10.4	7.7	6.3	6.2	7.1	6.2	6.1	8.6
All Other	13.3	29.7	25.8	22.4	20.7	18.5	18.6	16.2	16.3	9.6

* Wholesale merchants in this tabulation include importers, supply and machinery distributors and wholesale merchants.

and metal work (except iron and steel) are an extreme example of the range in this ratio of expense to sales. Establishments in that business making an average of more than $1,000,000 annual net sales spent $1.60 for every $100 of sales, while those averaging less than $25,000 spent $37.80.

Certain types of business which are carried on mainly outside the cities of 100,000 inhabitants or more—such as farm products, farm supplies, general merchandise, etc.—have expenses which are well below the average in their relation to net sales. The apparent indication from this fact, that location in a more rural area is an advantage in this respect for a wholesale establishment, is, however, fictitious. A comparison of the relative expenses of establishments in the same kind of business located in cities of 100,000 or more with the expenses of those in other territory, in representative areas of the country, shows that in a majority of the kinds of business expenses take a lower proportion of the net sales of establishments in the cities. Evidently the saving which accompanies location in smaller places is not usually sufficient to offset the effect of relatively smaller sales per establishment, and any advantage arises more from the volume of sales and the type of goods handled than from the location of a business.

Relative expenses naturally tend to be lower in lines where the goods handled are so standardized that only small selling expense is involved or where the business has a rapid turnover. The lowest expenses among wholesale merchants are found in the case of dealers in raw silk, a commodity of small bulk with its grades standardized; in 1929 they spent an average of $1.90 for every $100 of sales. The highest average is found among dealers in toilet goods and preparations, who spent $33.70 per $100 of sales.

It should perhaps be emphasized that all these figures apply only to wholesale merchants who perform all the usual wholesale services. For various reasons, relative expenses among other groups of wholesalers are generally lower. In the case of manufacturers' sales branches, for example, the average volume of net sales per establishment is very high, while among brokers who do not have warehousing expenses and wholesalers who offer only limited service there are fewer items to be included as expenses.

Trade Territories

The area within which concerns normally sell is of special interest to the communication industries. Whether a trade territory measures the area within which there is an effective demand for a given product or whether it merely represents the limits which present organization permits a firm to cover, knowledge of where the majority of the sales are made is useful in furthering the use of communication facilities in the sale of merchandise.

There is no means of determining exactly from the census data where the goods sold at wholesale are delivered. However, two studies of special trades, based partially on data not included in the general census reports, are now available and show for the wholesale hardware and electrical trades the market radius of firms located in 18 strategic cities in various parts of the country.

Establishments in these cities which are engaged in distributing hardware at wholesale do nearly half of the total wholesale hardware business in the country. Over half of their total business is done by dealers whose operations fall within a radius of 500 miles or, in other words, whose most distant customers are not more than an overnight trip away. In spite of the fact that these cities include the largest distributing centers in the country, only 7 per cent of the business is done by companies operating on a nation-wide scale. One-third of New York's sales are made by firms selling within a 75-mile radius and more than another third by concerns with a business either nation-wide or including an export trade. In the case of the electrical trade, the business done by wholesale houses in these same cities (constituting 69.4 per cent of the total of such business in the United States) is even more concentrated. Nearly half is done by concerns operating within a radius of 150 miles and only 4 per cent is done by firms with a national business.

Number of Marketing Units

Considerable public attention was attracted to the growth of multi-unit businesses in retail trade during the 1920–1930 decade, but it was not generally appreciated that this type of organization was also common in wholesale trade. As a matter of fact, by 1929 multi-unit organizations had made greater inroads into the wholesale merchant's field of activity than the chain store had made into the business of the independent retailer. About 36 per cent of the wholesale establishments were parts of large organizations doing 48 per cent of the total trade, while in the retail trade only 20 per cent of the establishments were other than single-store independents and this 20 per cent made only 36 per cent of the total sales. Of the business done by the largest organizations, those with 100 units or more, 40 per cent was done by the distributors of meats and 30 per cent by petroleum companies.

Sales by Commodities

The completeness of the records kept by the wholesale trade is illustrated by the fact that, for census purposes, it was possible for the trade to report 89.1 per cent of the total net sales in the United States subdivided by commodities. Concerns handling farm products and supplies, groceries and food products—in each of which there are almost innumerable items—were able to furnish the least detail, but in all others of the 24 major kinds of business over 90 per cent, and in some cases nearly 100 per cent, of the sales could be broken down by commodities. (The census schedule provided for reports on 92 major commodity lines.)

The most striking fact brought out by the figures of sales classified by commodities is the wide choice of wholesale outlets open to a producer and the extensive overlapping of all kinds of business. In general, wholesale trade is considerably more specialized than retail, and to a large extent the sales of a commodity are concentrated within a particular line of business; but the remainder of the sales of this commodity are apt to be found scattered throughout almost the entire list of kinds of business. This is especially true of products where the average unit value of the commodity is small and where final distribution will take these products to every part of the country. This situation means, of course, that not only do producers have a wide choice of channels for their goods, but that wholesalers must face competition from many different, and perhaps unexpected, quarters. A dealer may specialize in, say, electrical appliances, equipment, and supplies. He would expect competition from other dealers of all types in the electrical trade and, in the case of some of his lines, from the automotive trade, from hardware and machinery wholesalers, and from house furnishings dealers. The census shows, however, that in addition such goods are sold by the amusement goods trade, the chemical and drug trade, dry goods and apparel merchants, the leather trade, lumber and building materials concerns, dealers in metals and minerals, paper products, and petroleum, and even by tobacco merchants.

Another phase of this tendency for a commodity to be distributed through so many different kinds of business is shown in the variety of goods handled by dealers in any one line. It seems probable that these two tendencies interact on one another, and that as dealers find competition keener in their own specialties they begin to take on supplementary lines, thereby increasing the competition to be met by dealers specializing in those lines. At least 50 per cent, and frequently a much higher percentage, of a merchant's sales are made in one class of product, but the remainder may be divided among a surprising number of commodities. For example, two-thirds of the sales of the dealers comprising the machinery, equipment and supplies (except electrical) trade were sales of machinery and equipment, while the remaining one-third was divided among some 70 commodities, many of them closely related products but also including as diverse products as confectionery and soft drinks, jewelry, and stationery.

RETAIL TRADE

The figures on retail trade reported by the Census of Distribution probably have a smaller claim to accuracy than do those on wholesale trade. The average volume of business per establishment is far smaller ($32,000 annually as against $408,000), the line of goods carried is frequently much more varied, and complete accounts are not so universally kept. Moreover, in any interpretation of the statistics, more qualifying elements must be considered. Consequently, only conclusions based upon the more general figures can clearly be valid.

The 1,543,000 retail stores in the United States in 1929 transacted a total business of $49,114,653,000. The average size of business was thus $31,827, but over 43 per cent of the stores made sales of less than $10,000 while 1 per cent made sales of more than $300,000. In general, the location of both stores and sales follows the distribution of population more closely than in the case of wholesale trade, but it is influenced, too, by a number of factors: the purchasing power of the area, the drawing power of the large and varied retail establishments in cities and their constantly increasing accessibility, the proportion of food grown for home consumption in any area, the disregard by purchasers of state lines in their choice of buying centers and the degree to which mail-order buying is in favor.

The structure of retail distribution has become more and more complex under the stress of changing market conditions; the prevailing tendency in recent years towards concentration of production and the desire to develop cheaper methods of distribution in order to keep pace with the efficiency of production have led to a similar concentration of purchasing and planning in the retail field. The modern chain store is part of a system in which the merchandise planning and buying are centralized in an organization at headquarters and a central warehouse is used to accumulate and distribute merchandise to the various units as it is needed. However, single-store independent merchants still operate 80 per cent of the retail stores of the United States and do 64 per cent of the total retail business. The total retail business was distributed among the various types of organization in 1929 as follows:

	Per Cent
Single store independents	64.11
Local multi-unit independents	8.84
Local chains	6.71
Sectional and national chains	12.52
All other types of operation	7.82

The "all other" types of operation include the catalog business done by mail-order houses which, while an important channel of buying for some rural areas, amounts to only 1.05 per cent of the retail trade of the country. The sales made in the retail stores established by these concerns in a number of large cities are included in the sales of national chains. Other types of outlets are manufacturer-controlled chains such as are maintained by the makers of certain typewriters, plumbing equipment, etc., house-to-house selling, utility-operated retail stores, and leased department chains, mainly in department and apparel stores.

Certain features of chain store selling make it more adapted for use in urban than in rural territory. The costs of moving goods from wholesale centers and the uncertainty of a quick turnover are drawbacks to chain operation in remote areas, and the specialized line of goods and the emphasis placed upon cash dealings make such establishments ill-suited to many rural districts. Consequently the percentage of the total retail sales made in the several states by chains is closely related to the percentage of the population living in urban territory. Rhode Island, with 23 per cent of its retail sales made by chain stores, shows the highest proportion (except for the District of Columbia, with 25 per cent), and Mississippi the lowest, with slightly more than 7 per cent.

The kinds of stores as well as the types of organization are determined to some extent by the type of community. Highly specialized stores such as book stores, shoe stores, women's ready-to-wear apparel stores, and certain types of food stores can exist only in areas of concentrated population or in suburban areas with high purchasing power. Sparsely populated areas can only support (and can be well served by) the more general store, ranging from the department and variety stores found in most cities of whatever size down to the country general store.

Commodities Sold by Retail Stores

The data reported by the census as to the lines of goods sold by the various types of stores are of little general interest, but may be useful in case it is desired to obtain an idea of the approximate distribution by commodities of the total sales by a particular type of store. At best, the figures are rough approximations, since it was impossible to obtain records of the commodity sales of a large share of the retail establishments. Large organizations such as department stores and stores handling a relatively small number of different lines, such as automotive dealers, were able to report in detail, but the multitude of small neighborhood stores keep no classified records.

From the figures that are given, however, it is clear that the outlets for retail goods are of the greatest variety and that the type of store which predominates in the total sales of a commodity depends upon local conditions rather than upon what appear to be its logical channels. Local prejudices, the special merchandising ability of some dealers, and the economic status of the community are apt to be the deciding factors.

Expenses of Retail Selling

The average expense of carrying on a retail business is about double that of doing a wholesale business, if expenses are measured as a percentage of total sales. The average retailer's cost in the United States was $24.83 per $100 of sales in 1929. The necessity for being well located makes the average rent fairly high, and the wages of sales people amount to a higher proportion of the sales than in wholesale trade.

Retail Sales as a Measure of Purchasing Power

The distribution of retail stores and sales throughout the United States indicates in a broad way the buying power of the population in various sections of the country. There are, however, exceptional conditions which must be considered in evaluating the figures on this subject. It should always be borne in mind, in the first place, that stores must be established in strategic locations and, in the second place, that the census figures were collected on the basis of political subdivisions and not with regard to the buying habits of a population group. Taking the case of the rural territory as an example: According to the population census 30,000,000 people, almost 25 per cent of all those in the United States, were living in 1930 on farms in the open country, where necessarily there are few stores. They are served, for some buying purposes, by stores in small towns and villages, but such stores can deal for the most part only in staple commodities in day-to-day demand. Consequently, both the farm and the village population depend upon somewhat larger communities for other types of goods. However, in spite of the fact that its residents make some of their purchases in other localities, the area outside cities of 10,000 or more inhabitants reported 44 per cent of the retail stores and 30 per cent of the retail business in 1929; clearly, with 53 per cent of the country's population, it is an area not to be neglected as a market possibility.

The extent to which the trade territories of cities of 10,000 and over reach into the surrounding area is often of interest. The overlapping of the tributary areas of large places frequently makes it difficult to obtain data for a single city; but an analysis of 14 middle-western and southern cities (ranging in size up to 400,000 inhabitants) indicates that such communities dominate the retail buying of the remainder of the counties in which they are located and that there is about an even chance that this influence will extend through the adjacent counties. In each case the part of a county outside the city of 10,000 or more showed a much smaller proportion in respect of the total retail business done in the corresponding area of the state than it did in respect of the proportion of various facilities which may be regarded as indicators of purchasing power, such as radios, residence telephones or domestic electric meters.

While the large city evidently exerts a considerable pulling power over its surrounding territory, broad areas exist in which there are no sizeable cities. In fact 2,457 counties, or 80 per cent of the total number in the United States, have no place as large as 10,000 population. In these regions the county seat is apt to be the principal trading center. It is ordinarily located near the center of the county and is reached by the best of the county roads; its position as the center of local government and the headquarters of county organizations adds to its drawing power. A study made by the Census Bureau of the retail business done in a representative sample of these communities indicates that the volume of retail business transacted in them usually far exceeds the volume warranted by their population alone.

County Seat Towns Analyzed	Number	Per Cent of Total
Total	727	100
Doing over 50 per cent of County Business	444	61
Containing over 50 per cent of population of these counties	26	
Containing from 25 to 50 per cent of population of these counties	183	
Containing less than 25 per cent of population of these counties	235	
Doing from 30 to 50 per cent of County Business	182	25
Containing over 50 per cent of population of these counties	—	
Containing from 25 to 50 per cent of population of these counties	3	
Containing less than 25 per cent of population of these counties	179	
Doing less than 30 per cent of County Business	101	14

While the county seat is frequently the largest incorporated place in the county, its attraction as a shopping center tends to be greater than that of other places of the same size. In Ohio, for example, there are 91 places of between 1,000 and 5,000 population in counties where there are no cities of 10,000 or more. Of the 91 towns, 29 are county seats, in which the average retail sales per capita in 1929 were $760, while in the remaining 62 the average was $568 per capita.

Since there exist these special conditions which influence the buying habits of localities, the question may be raised as to what value the retail sales figures have as a measure of market. A test made of the retail sales per family in the rural counties of Ohio, Alabama, Missouri and Oregon—areas representing diverse economic conditions—indicates that the relative grade of a rural market is likely to appear approximately the same measured by an index of retail sales as by one based on several items, including the number of radios, passenger automobiles and domestic electric meters per 100 families. It is also true that the average sales per establishment among the kinds of stores most common in rural areas are almost consistently high in regions which might be judged from other measures to be good markets, while a large proportion of sales made in country general stores and a high density of such stores are usually associated with poor market areas. It seems that the greatest value of the retail sales data in general will be gained from their use in conjunction with other indications of the type of the market, including data on the characteristics of the population and its economic activities as well as on the extent to which certain facilities have already been sold. It also appears that retail sales per family used alone can be considered a valid measure of the market in areas not too strongly affected by the influence of near-by cities.

CONCLUSION

The nature of the distributive function makes the field of distribution a large potential market for telephone service. The distance often existing between wholesalers and retailers, added to the need of keeping retail stocks constantly at a reasonably high level, should make the telephone a natural connective link. Moreover, determination of the location of the best markets is an essential part of the procedure of bringing together materials of scattered origin for processing and distributing the finished products to retailers and ultimate consumers. This is perhaps especially important in the case of perishable commodities which undergo no processing beyond sorting and packing, but which must reach the proper markets promptly.

The Census of Distribution shows that wholesale trade tends to be concentrated in the largest cities and that the great number and variety of outlets, both wholesale and retail, make possible a choice of channels by the producer or distributor of any commodity and provide the dealers themselves with a problem in competition. It also indicates that a considerable proportion of the total transactions involved do not take place according to the popular conception of the distributive process.

In the retail field the fact that the independent dealer still maintains his pre-eminent position in spite of various kinds of competition is brought out by the census figures. Equally interesting and useful are the facts shown as to the influence of large cities on the buying habits of their surrounding areas and the importance of county seats as trading centers in areas where there are no large urban places. It seems probable that local telephone usage and local toll usage stand to gain as urban retail merchants develop their facilities for handling telephone business and as their trade territories tend to expand further into rural areas.

The retail sales data will be important to many in that they provide a new measure of potential markets. Retail sales per family appear to rank with other indexes already widely used. These data are probably somewhat less reliable than the other measures in highly urbanized territory if used alone, but in conjunction with other indexes should make possible a well-based decision as to the quality of the market offered by any particular area.

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